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STEVENS CREEK DROP STRUCTURE MODIFICATION PROJECT

PHYSICAL HYDRAULIC MODEL STUDY

FINAL REPORT

Prepared For:

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1.0 INTRODUCTION

1.1 GENERAL

A hydraulic model study was conducted by **northwest hydraulic consultants** (**nhc**) to assist in developing a water-level to flow discharge relationship to be used as the rating curve for the modified Stevens Creek Drop Structure. This study was conducted in accordance with an agreement between Santa Clara Valley Water District (SCVWD) and **nhc** dated October 23rd, 2002 (SCVWD PO# SO 200310208).

Notice to Proceed on the model study was received October 28, 2002. The model design and construction started November 4th, 2002 and were completed December 13th, 2002. Model testing commenced immediately following construction and was completed during the second week in January 2003. A witness test was held at **nhc**'s laboratory on January 23rd, 2003.

Liaison for the study was maintained with Mr. Liang Lee of SCVWD. The study was conducted under the direction of Mr. Ken Christison of **nhc**.

1.2 PROJECT DESCRIPTION

Stevens Creek is a 30 km (19 mile) long river, originating from the Santa Cruz Mountains of the California Coast Range, flowing through the cities of Cupertino, Los Altos and Mountain View before discharging into San Francisco Bay. The project site is located immediately upstream from the Highway 85 crossing near the end of Central Avenue in the city of Mountain View, California. In the 1950's a series of tall horizontal concrete steps was constructed to control water levels upstream from Highway 85. The SCVWD established Stream Gage Station 35 upstream from the concrete steps to measure discharge in the creek. Although these steps created an ideal control structure for measuring discharge and water levels they also imposed a barrier for migratory steelhead trout.

The Stevens Creek Drop Structure Modification Project was developed to maintain the SCVWD's Stream Gage Station 35 without impeding fish passage. The concrete steps were replaced by four weirs in the fall of 2002. The weirs, Figures 1-1 to 1-3 and Photo Plate 1-1, are V-shaped in both vertical and horizontal planes and have a 26 cm (0.86 ft) drop from weir to weir at the low center notch. This slight drop in elevation allows fish to pass during most of the flow season when steelhead are migrating.

SCVWD Stream Gage Station 35 is located immediately upstream of the new drop structure. Communication pipes extending to the center of the creek allow the water level to be measured in the gage at the right bank (looking downstream) of the creek. Photo Plate 1-2 (1) illustrates the location of Stream Gage Station 35. Photo Plate 1-2 (2) illustrates the riprap and grouted concrete over the communication pipes.

The stream channel banks are heavily vegetated upstream from the gage station (Photo Plate 1-2). Downstream from the drop structure Stevens Creek flows approximately 60 m (200 ft) under Highway 85. The section of channel is lined with concrete and sack concrete, Photo Plate 1-3 (1). A 1 m (3 ft) drop, located near the downstream end of the Highway 85 bridge piers, acts as a hydraulic control during low to normal flows, Photo Plate 1-3 (2). However, at higher flows the weir becomes submerged. Downstream from Highway 85 the banks remain steep and heavily vegetated, Photo Plates 1-3 (3).

Historically, the horizontal concrete steps occasionally retained sediment. However, collected sediment was often sluiced downstream during higher flow events (personal communication with Liang Lee of SCVWD), resulting in little permanent sediment deposition within the structure. Prior to the construction of the new drop structure, bed samples were used to determine the sediment characteristics within the channel. The results from these tests are presented in Appendix A. Sediment is expected to deposit from time to time within the recently constructed V-baffle drop structure. Photoplate 1-2 (2) shows evidence of initial deposition.

The correlation of flow frequency with fish migration at Stevens Creek Stream Gage Station 35 for a 42 year period by SCVWD indicated that historically over 90% of observed fish migration occurred at flows ranging between approximately 0.17 and 4.0 m^3/s (6 and 140 cfs). The results are presented in Appendix A.

1.3 MODEL STUDY OBJECTIVES

The primary objective of this model study was to develop a water-level to flow-discharge relationship to be used as a rating curve for the gage. The model was also to be used to verify the performance of the drop structure in terms of fish passage and sediment sluicing.

2.0 MODEL DESCRIPTION

2.1 SIMILITUDE AND SCALE

Scale hydraulic models require that the force relationships in the model and prototype are dynamically similar. To achieve complete similarity, the ratios of the inertia to the gravitational, viscous, and surface tension forces must be the same between model and prototype. Since only a 1:1 scale model can achieve all these criteria simultaneously, modeling at reduced scale involves identifying the primary force relationship to best simulate prototype conditions, then selecting a model scale to minimize any resulting scale effects. For free-surface flow conditions of the type being examined in the present investigation, the gravitational force is the dominant force that defines the hydrodynamic flow conditions, and the ratio of the inertial to gravitational forces, represented by the Froude number, must be equal in the model and prototype. That is,

$$F_r = \frac{F_M}{F_P} = 1$$

where, $F_M = \textit{Froude number in the model} = \dfrac{\textit{Inertial Force}}{\textit{Gravitational Force}} = \dfrac{U_M}{\sqrt{g\,L_M}}$

$$F_P = \textit{Froude number in the prototype} = \frac{U_P}{\sqrt{g\,L_P}}$$

and, *U = characteristic flow velocity,*

g = gravitational acceleration, and

L = characteristic length

M = model values, and

P = prototype values

For the Stevens Creek Drop Structure Modification Project, **nhc** constructed and tested a 1:18 scale model. Model operation adherenced to the Froude criterion for dynamic similarity, leading to the following scale ratios:

Model Scale Relationships

Parameter	Relationship	Ratio
Length	L_T	1 : 18
Velocity	$L_T^{1/2}$	1 : 4.24
Discharge	$L_T^{5/2}$	1 : 1,375

2.2 MODEL DESCRIPTION

The model, as shown in Figure 2-1 and Photo Plates 2-1 to 2-3, accurately represented a 150 m (500 ft) long reach of Stevens Creek. The model extended approximately 25 m (80 ft) upstream from the SCVWD's Stream Gage Station 35, and 15 m (50 ft) beyond the downstream control weir located between the Highway 85 bridge piers. This ensured that the appropriate approach and tailwater conditions were reproduced. The model was constructed as a fixed-bed model in accordance with bathymetric survey data supplied by the SCVWD.

The general model basin was constructed using standard framing materials and techniques. Sections upstream and downstream of the drop structure were constructed using a combination of acrylic plastic, dimensional lumber, and high density foam. The model was designed to ensure that the V-baffles were accessible during the test program. The drop structure, mounted on a raised wooden deck, used transparent acrylic plastic to facilitate observation, as shown in Photo Plate 2-2.

Care was taken to ensure that vegetation along the banks was modeled accurately. Perforated cloth representing head loss created by the vegetated banks upstream of Stream Gage Station 35 was installed in the model. A series of sensitivity tests was conducted to ensure that the correct bank treatment was adopted for this study. Use of this process in the past by **nhc** has demonstrated that this technique accurately represents field conditions. The adopted bank roughness layout is presented in Photo Plate 2-1.

Downstream tailwater control based on a one-dimensional HEC-RAS analysis by SCVWD indicated that for flows below 113 m^3/s (4,000 cfs), the tailwater was controlled by the 1 m (3 ft) vertical drop located near the downstream end of the Highway 85 overpass. The HEC-RAS simulation indicated that flows above 113 m^3/s (4,000 cfs) produced depths in the downstream channel that gradually submerge the drop. Therefore, at flows below 113 m^3/s (4,000 cfs) the model tailgate was left fully open, allowing water to passing freely over the 1m (3 ft) drop. At flows greater than 113 m^3/s (4,000 cfs), the model tailgate was adjusted to set the water surface according to the computed elevations presented in Table 2.1, shown on the following page.

A centrifugal pump drew water from a laboratory sump below the model. The total model inflow was controlled with a butterfly valve installed in the pipe that supplied the model triangular weir box, located at the upstream end of the model. Flow requirements in the model ranged from 0.12 to 171 liters per second (l/s) (0.004 to 6.04 cfs).

TABLE 2.1

Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Stevens Creek Hydraulic Analysis Using HEC-RAS[1]
River Station 62[2]

Steven's Creek Discharge		Water Surface Elevation	
m^3/s	cfs	m	ft
113	4,000	18.5	60.6
142	5,000	19.0	62.4
170	6,000	19.4	63.8
198	7,000	19.8	65.1
227	8,000	20.2	66.2

Note: 1) Analysis conducted by SCVWD
2) River Station 62 is located at the 1m (3 ft) drop end of the Highway 85 bridge crossing

2.3 SIMULATION OF SEDIMENT

Model sediment material, used to qualitatively assess the sediment sluicing capabilities of the drop structure, was scaled to simulate the bed material gradation information provided in the RFP and presented in Appendix A. Sediments used in the model were adjusted so that the model and prototype material D_{50} settling velocities were consistent with Froude sealing. For this study the prototype D_{50} size 6.0 mm corresponds to a settling velocity of 25.0 cm/s. The scaled settling velocity for the model material is 5.9 cm/s which corresponds to a model D_{50} particle size of 0.40 mm. A similar calculation was conducted for both the prototype and modeled D_{10} and D_{90} particle sizes. The resulting theoretical and adopted grain sieve analyses are presented with the prototype data in Appendix A.

2.4 MODEL CONTROLS AND INSTRUMENTATION

The following measurements were required in the model:

Model Discharge - The model flow was circulated with a centrifugal pump, regulated with a butterfly valve, and measured with an orifice plate before discharging into a standard v-notched weir box. Flow entered the triangular weir box diffused upward through a horizontal slotted diffuser before passing over the triangular weir and into the model headbox. Flow entering the headbox passed through a vertical slotted diffuser as it entered the model basin. The headbox was designed to provide a uniform distribution of flow approaching the modified drop structure.

The orifice plate was sized and installed in accordance with American Society of Mechanical Engineers (ASME) standards. The discharge was monitored continuously for the duration of each test. Experience with these discharge systems indicates an error of less than 2 percent is expected. The triangular weir acted as a redundant flow measuring device to further improve the accuracy of modeled discharge.

Water Levels - Measurement of water levels upstream of Gage Station 35, at Gauge Station 35, through the drop structure, and downstream of the project was achieved using flush-mounted piezometric pressure taps connected to calibrated stilling wells where the water levels were measured with precision point gages. Twelve pressure taps were installed and monitored in the model.

The datum elevations for each of the water level measurement devices were established as part of model calibration utilizing standard survey instruments, and were checked on a regular basis to ensure accurate measurement throughout the testing program.

Flow Patterns - Flow patterns as they relate to fish passage approaching the drop structure, between the baffles, and immediately downstream from the drop structure were documented using video footage, still photography, hand-drawn sketches and written observations. Application of dye solutions and floating tracers were used to improve the visualization of the flow patterns.

Photography and Video – Still photographs and video footage were taken throughout the test program to provide a detailed visual documentation of the model study. Relevant photographs have been included in this report.

3.0 TEST PROGRAM

To provide the most efficient and cost-effective test program, **nhc** conducted a two-phase program that determined the water-level to flow-discharge relationship, and verified the performance of the drop structure in terms of fish passage and sediment sluicing. The two phases, as described in the following sections, include:

1) Rating Curve and Fish Passage Documentation
2) Sediment Impacts on Predicted Rating Curve and Flow Patterns

3.1 RATING CURVE AND FISH PASSAGE DOCUMENTATION

Upon completion of model construction and shakedown (tests to ensure that the model was functioning effectively over the full range of operating conditions, and that the instrumentation was properly calibrated and fully functional), a range of flows was used to develop a water-level to flow-discharge relationship. Flows were tested ranging from 0.16 to 235 m^3/s (6.0 to 8,300 cfs). Data collected during each test included the model discharge and water level measurements along the full reach of the model. In addition, during three of these tests, flow patterns within the V-baffle drop structure were documented using video, photographs and manual sketches. Additional flow conditions were documented for fish migration flows.

The first phase of testing developed an accurate water-level to flow-discharge relationship and provided a description of flow patterns as they pertain to fish passage for the proposed structure.

3.2 QUALITATIVE ASSESSMENT OF SEDIMENT EFFECTS ON RATING CURVE AND FISH PASSAGE

Upon completion of the first phase of testing, the model was run with a sediment tracer. Tests conducted to identify flow patterns in the vicinity of the proposed drop structure were also adopted for this series of tests. Sediment scaled to depict the channel's grain size characteristics (provided by the SCVWD) was placed in the model upstream of the control structure. Once a steady state sediment deposition was attained, the water-level to flow-discharge relationship, flow and deposition patterns along the drop structure were recorded. The effects of sediment bed material deposited on the water-level to flow-discharge relationship and flow patterns were observed.

This second series of tests determined the effect of sediment deposited on either the water-level to flow-discharge relationship or fish passage in and around the drop structure.

4.0 TEST RESULTS

4.1 WATER-LEVEL TO FLOW-DISCHARGE RELATIONSHIP

Numerous data sets were acquired to determine the sensitivity of the water-level to flow-discharge relationships relative to various modeled upstream bank vegetation. Three data sets were adopted for additional analysis. The first data set was acquired without bank treatment, allowing flow to pass unimpeded. The second data set was acquired with a perforated cloth defining the perimeter of the vegetated banks. The third data set modeled bank vegetation in a zig-zag pattern as illustrated in Photo Plate 2-1. The data defining all three initial water-level to flow-discharge relationships are presented in Figure 4-1.

Data from the three tests indicated Stream Gage 35 water levels were sensitive to the type of resistance used to simulate the vegetated bank. The data sets compared well during flows below 28.3 m^3/s (1,000 cfs). However, above 28.3 m^3/s (1,000 cfs) the increase in bank resistance significantly increased velocities along the center of the channel and over Stream Gage 35. The accelerated flow reduced water levels within the channel upstream of the V-baffles and therefore at Stream Gage Station 35.

From the photographs provided by SCVWD it appears that flow will be able to pass through the vegetation along the banks. For this reason the data set developed from the zig-zag pattern was selected for additional testing. The suggested rating curve with the accompanying data is presented in Figures 4-2 and 4-3. The rating curve presented in the equation below and in Figures 4-2 and 4-3 indicates that, at 4.0 and 113 m^3/s (140 and 4,000 cfs), the water surface elevation at Stream Gage 35 is 17.2 and 20.0 m (56.5 and 65.5 ft), respectively.

$$\text{WSE} = \left| \begin{array}{l} 54.30 + 0.21 \text{ x } Q^{0.48}, \text{ for discharge less than } 113 \text{ m}^3\text{/s (4,000 cfs)} \\ 54.30 + 0.07 \text{ x } Q^{0.61}, \text{ for discharge greater than } 113 \text{ m}^3\text{/s (4,000 cfs)} \end{array} \right.$$

where, WSE is the water surface elevation in feet (ft) and
Q is the discharge in cubic feet per second (cfs)

4.2 FISH PASSAGE FLOW PATTERNS

Flow frequency analysis for the migration at Stevens Creek Gage Station 35 conducted by SCVWD indicated that over 90% of fish migration occurred between flows of 0.17 and 4.0 m^3/s (6 and 140 cfs). Detailed documentation of flow patterns over the drop structure was collected in the model at flows of 0.55, 1.9, and 4.0 m^3/s (20, 66, and 140 cfs), which correspond to 70, 25, and 5% exceedence flow conditions. The observed flow patterns, Figures 4-4 to 4-6, indicated that during fish migration the flow plunging over each V-baffle is focused along the center of the channel. Recirculation zones along the banks of the three upstream pools direct flow toward the upstream baffles. The flow distribution in the furthest downstream pool becomes rather uniform as flow approaches the broad crested channel under Highway 85.

The Stevens Creek Drop Structure Modification Project was developed to maintain the SCVWD's Stream Gage Station 35 without impeding fish passage. The V-shaped weirs are designed to have a 0.26 m (0.86 ft) drop from weir to weir at the low center point. This slight drop in elevation allows steelhead to migrate upstream over the control structure. The measured head drop over the V-baffle weirs is presented in Table 4.1.

TABLE 4.1

Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Head Drop over the V-Baffle Weirs During Fish Migration

Discharge		Station	Water Surface Elevation		Head Drop	
m^3/s	cfs		m	ft	m	ft
0.57	20.2	Stream Gage 35	16.80	55.1		
					0.18	0.59
		Pool 1[1]	16.62	54.5		
					0.26	0.84
		Pool 2[2]	16.36	53.7		
					0.28	0.91
		Pool 3[3]	16.08	52.8		
					0.36	1.19
		Pool 4[4]	15.72	51.6		
1.88	66.4	Stream Gage 35	17.01	55.8		
					0.11	0.37
		Pool 1	16.90	55.4		
					0.26	0.86
		Pool 2	16.63	54.6		
					0.29	0.96
		Pool 3	16.34	53.6		
					0.37	1.22
		Pool 4	15.97	52.4		
4.01	141.7	Stream Gage 35	17.26	56.6		
					0.17	0.55
		Pool 1	17.09	56.1		
					0.21	0.70
		Pool 2	16.88	55.4		
					0.27	0.89
		Pool 3	16.61	54.5		
					0.36	1.19
		Pool 4	16.24	53.3		

Note: 1) Pool 1 is located immediately downstream of Baffle 1
2) Pool 2 is located immediately downstream of Baffle 2
3) Pool 3 is located immediately downstream of Baffle 3
4) Pool 4 is located immediately downstream of Baffle 4

The elevation drop between each weir is 0.26 m (0.85 ft). The difference in water surface from Pool 1 to Pool 2, and Pool 2 to Pool 3 is approximately equal to the weir elevation difference, except for the water surface drop from Pooll 1 to Pool 2 for 4.01 m^3/s (141.7 cfs), which is 0.21 m (0.70 ft). The difference between the water surface elevation at Gage 35 and Pool 1 is considerably less than the weir elevation difference because of the high approach velocity upstream of Weir 1, which tends to depress the upstream water level. On the other hand, the water surface elevation drop from Pool 3 to Pool 4 is considerably higher than the weir elevation difference. This results from the downsream channel water surface elevation, which is controlled by downstream channel geometry.

4.3 SEDIMENT IMPACTS

4.3.1 SEDIMENT IMPACT ON WATER-LEVEL TO FLOW DISCHARGE RELATIONSHIP

To determine the impact sediment has on the water-level to flow-discharge relationship the pool upstream of each baffle was filled to the downstream baffle notch elevation. Model discharge was slowly increased to 0.55 m^3/s (20 cfs). The discharge was maintained until the scour patterns in each pool reached a steady state. The stage readings at Stream Gage 35 were then recorded. The flow was then increased to 1.9 m^3/s (66 cfs) and maintained until the scour pattern in each cell reached a steady state. This test was then repeated at a river flow of 4.0 m^3/s (140 cfs). The results from the three tests indicated that the water-level to flow-discharge relationship at Stream Gage 35 did not significantly vary from the sediment-free test. The results are presented in Table 4.2.

TABLE 4.2
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Sediment Impact on the Water-Level to Flow-Discharge Relationship at SCVWD Stream Gage Station 35

Discharge		Water Surface Elevation			
		Without Sediment[1]		With Sediment[2]	
m^3/s	cfs	m	ft	m	ft
0.6	20	16.80	55.1	16.79	55.1
1.9	66	17.01	55.8	17.01	55.8
4.0	140	17.26	56.6	17.22	56.5

Note: 1) Test conducted under design conditions prior to introducing sediment into the model.
2) Tests conducted with sediment desposition reaching equilibrium between the V-baffles

The largest impact sediment had on the rating curve was 0.04 m (0.1 ft). This variation in water surface elevation is negligible relative to the turbulent nature of flow expected in during fish migration flow conditions.

4.3.2 SEDIMENT IMPACT ON FISH PASSAGE FLOW PATTERNS

To document the impact sediment has on flow patterns within the drop structure the cell upstream of each baffle was filled to the downstream baffle notch elevation. Detailed documentation of flow patterns over the drop structure were collected in the model at flows of 0.55, 1.9, and 4.0 m^3/s (20, 66, and 140 cfs). The observed flow patterns, presented in Figures 4-7 to 4-9, were similar to flow patterns observed without sediment. During fish migration the flow plunging over each V-baffle was concentrated along the center of the channel. Along the banks of the three upstream pools, a recirculation zone directed flow toward the upstream baffle. The flow in the furthest downstream pool became uniformly distributed across the channel width as flow entered the channel under Highway 85, which terminated at a 3 ft vertical drop. The introduction of sediment reduced the cross-sectional area within the pool, when compared to the no-sediment case, creating more concentrated jet along the center of the channel.

Following the detailed documentation tests the discharge was increased from 17.0 m^3/s (600 cfs) in increments of 5.7 m^3/s (200 cfs). Scour between the baffle was allowed to reach a steady state at each discharge. Sediment upstream of each baffle was washed downstream at approximately 34.0 m^3/s (1,200 cfs). A recirculation pattern immediately downstream from each baffle collected a small amount of coarse sediment as shown in Photo Plates 4-1 to 4-5. Sediment deposited with the drop structure will be flushed downstream during flood events at or above 34.0 m^3/s (1,200 cfs). However, sediment is often re-deposited as flood flows recede. Field observations with the previous drop structure geometry also identified frequent downstream sluicing of deposited sediments during higher flow events (personal communication with Liang Lee of SCVWD). These sluicing patterns are expected to continue with the more efficient V-baffle geometry, as indicated by the model tests.

5.0 SUMMARY

5.1 RATING CURVE AND FISH PASSAGE

- The rating curve developed for SCVWD Stream Gage 35 is:

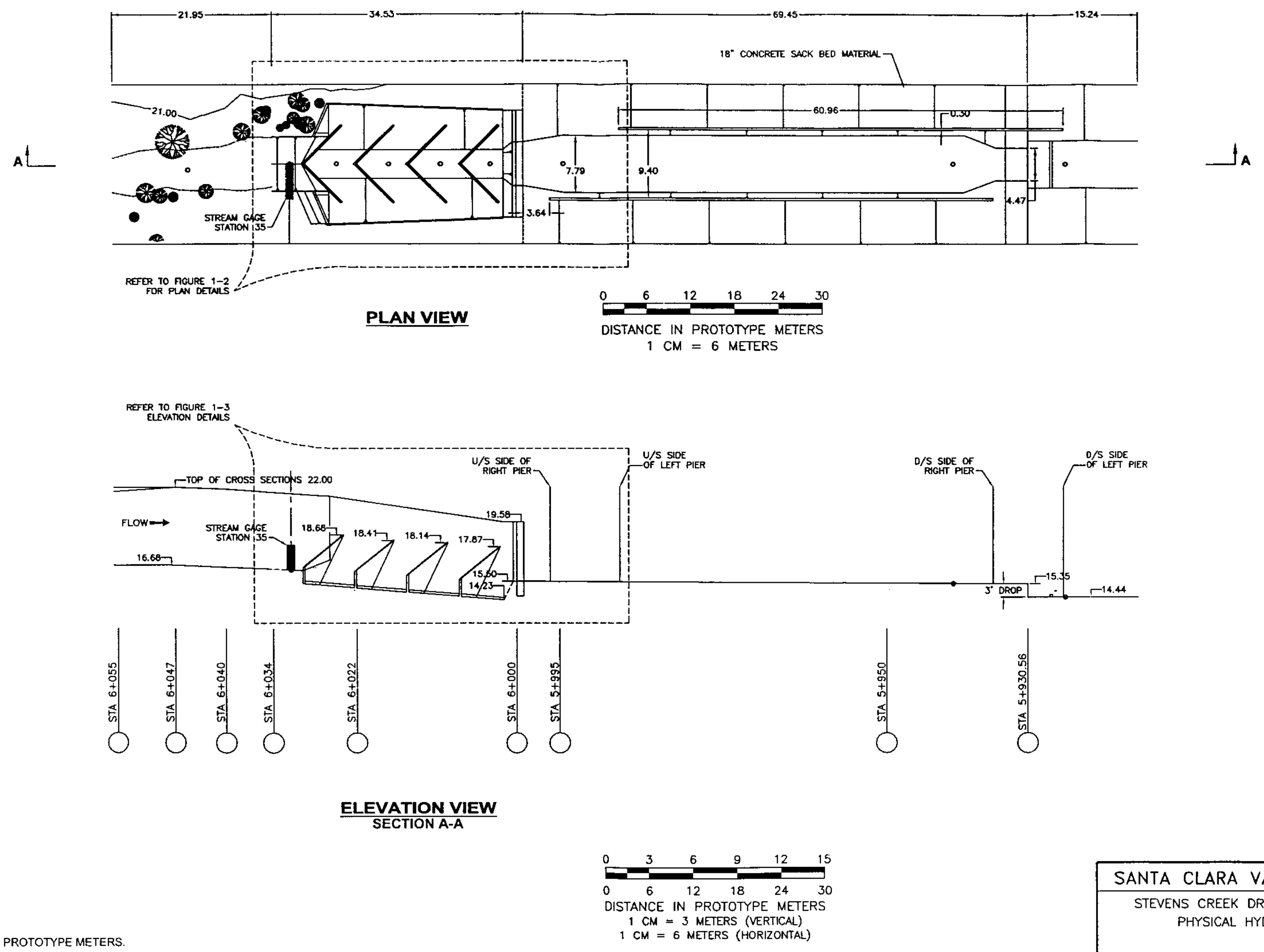
$$\mathrm{WSE} = \begin{cases} 54.30 + 0.21 \times Q^{0.48}, & \text{for discharge less than } 113\ \mathrm{m^3/s}\ (4{,}000\ \mathrm{cfs}) \\ 54.30 + 0.07 \times Q^{0.61}, & \text{for discharge greater than } 113\ \mathrm{m^3/s}\ (4{,}000\ \mathrm{cfs}) \end{cases}$$

where, WSE is the water surface elevation in feet (ft) and
Q is the discharge in cubic feet per second (cfs)

- During fish migration the flow plunging over each V-baffle concentrated along the center of the channel. A recirculation zone directed flow toward the upstream baffle along the banks of the three upstream pools. The flow distribution in the furthest downstream pool became more uniform as flow entered the channel under Highway 85.
- Piezometric head over the downstream baffles was greater than the design drop of 0.26 m (0.86 ft) during typical fish migration flows.

5.2 IMPACT SEDIMENT HAS ON RATING CURVE AND FISH PASSAGE

- Sediment deposition between the V-baffles had little impact on the Stream Gage 35 rating curve.
- Flow velocities between the V-baffles increased with large sediment deposits.
- Deposited sediment was flushed downstream during flood events at or above 34.0 $\mathrm{m^3/s}$ (1,200 cfs). However, deposition often occurs when sediment falls out of suspension as flood flows recede. Sediment collected by the previous drop structure geometry was often sluiced downstream during higher flow events (personal communication with Liang Lee of SCVWD). Sluicing patterns are expected to continue with the more efficient V-baffle geometry.



PLAN VIEW

ELEVATION VIEW
SECTION A-A

NOTES

1) DIMENSIONS GIVEN IN PROTOTYPE METERS.
2) CROSS SECTION DETAILS, SEE FIGURE 1-4

SANTA CLARA VALLEY WATER DISTRICT
STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Plan and Elevation View

3733-012	REV. NO. 0	Nov 5 2002

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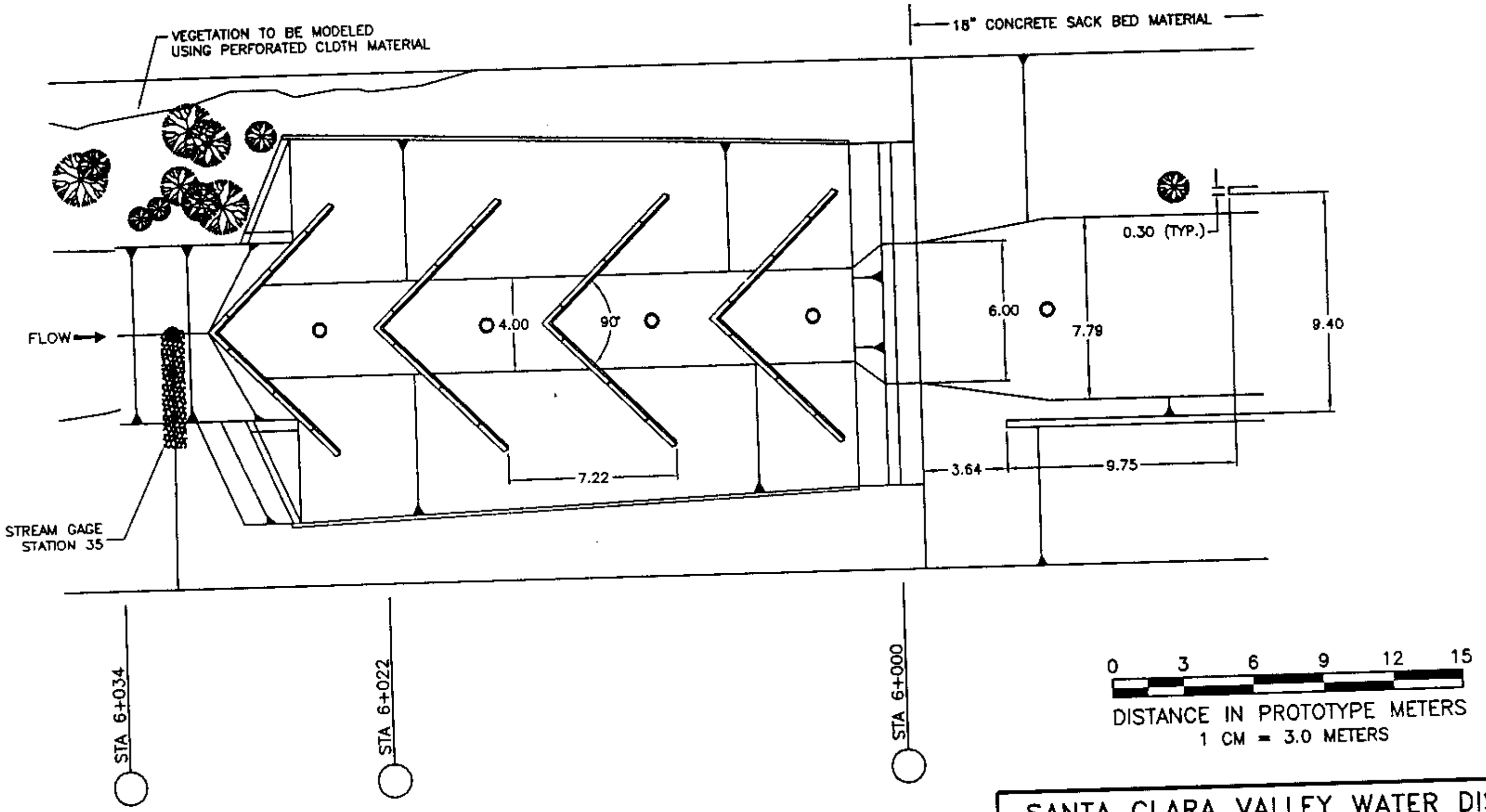
FIGURE 1-1



SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Plan View Details

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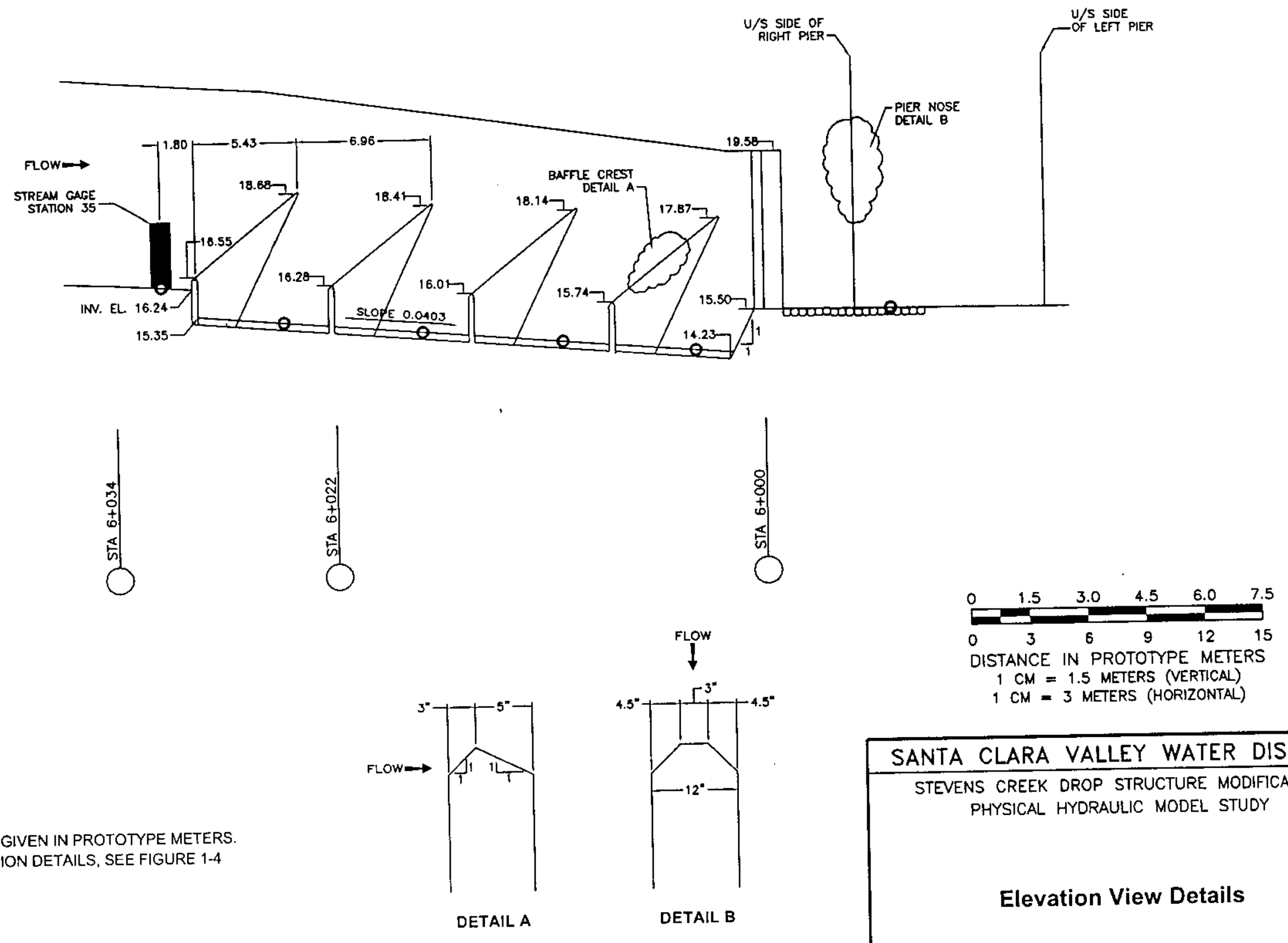
NOTES
1) DIMENSIONS GIVEN IN PROTOTYPE METERS.
2) CROSS SECTION DETAILS, SEE FIGURE 1-4

FIGURE 1-2



NOTES

1) DIMENSIONS GIVEN IN PROTOTYPE METERS.
2) CROSS SECTION DETAILS, SEE FIGURE 1-4

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Elevation View Details

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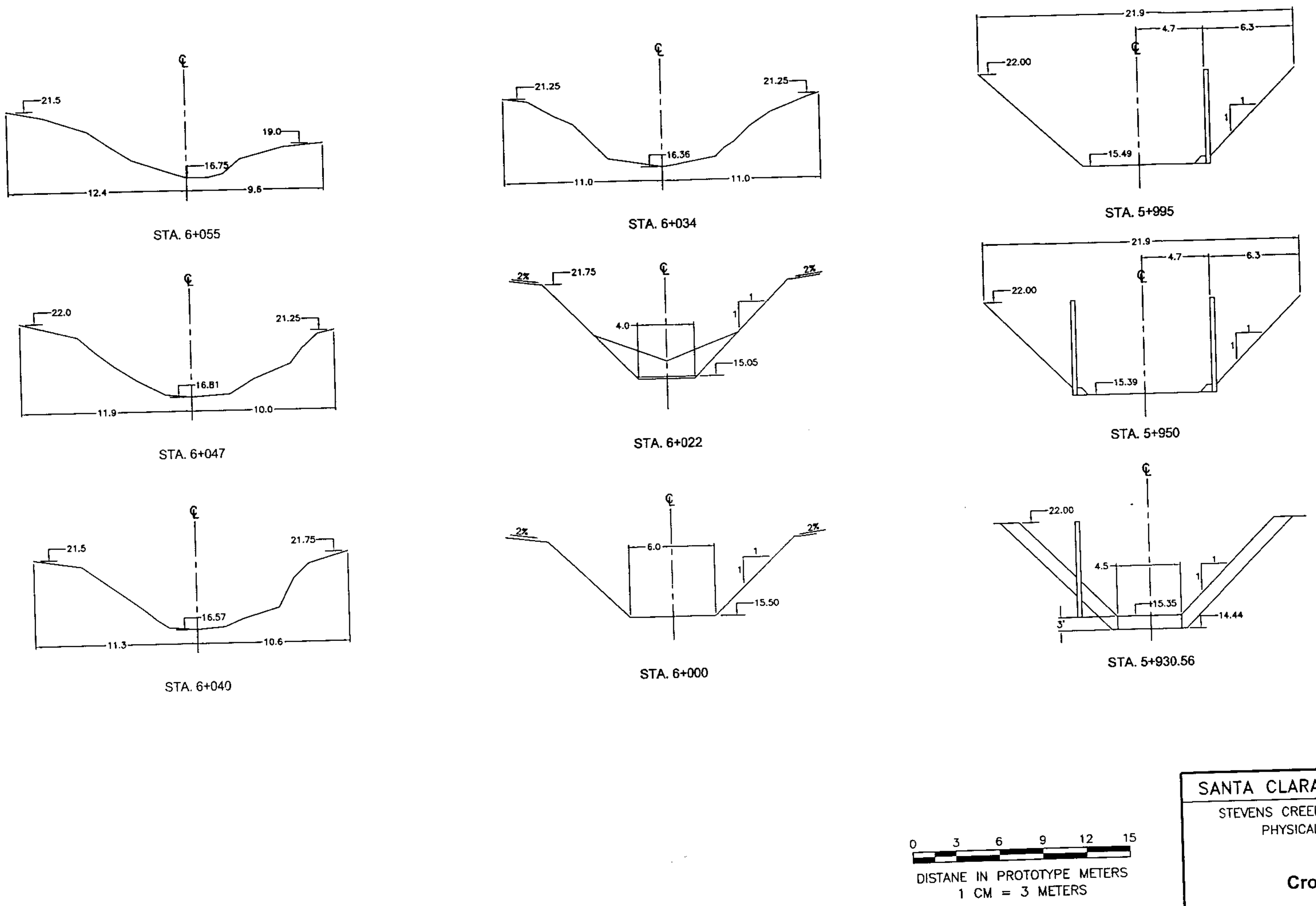
FIGURE 1-3



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STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Cross Section Details

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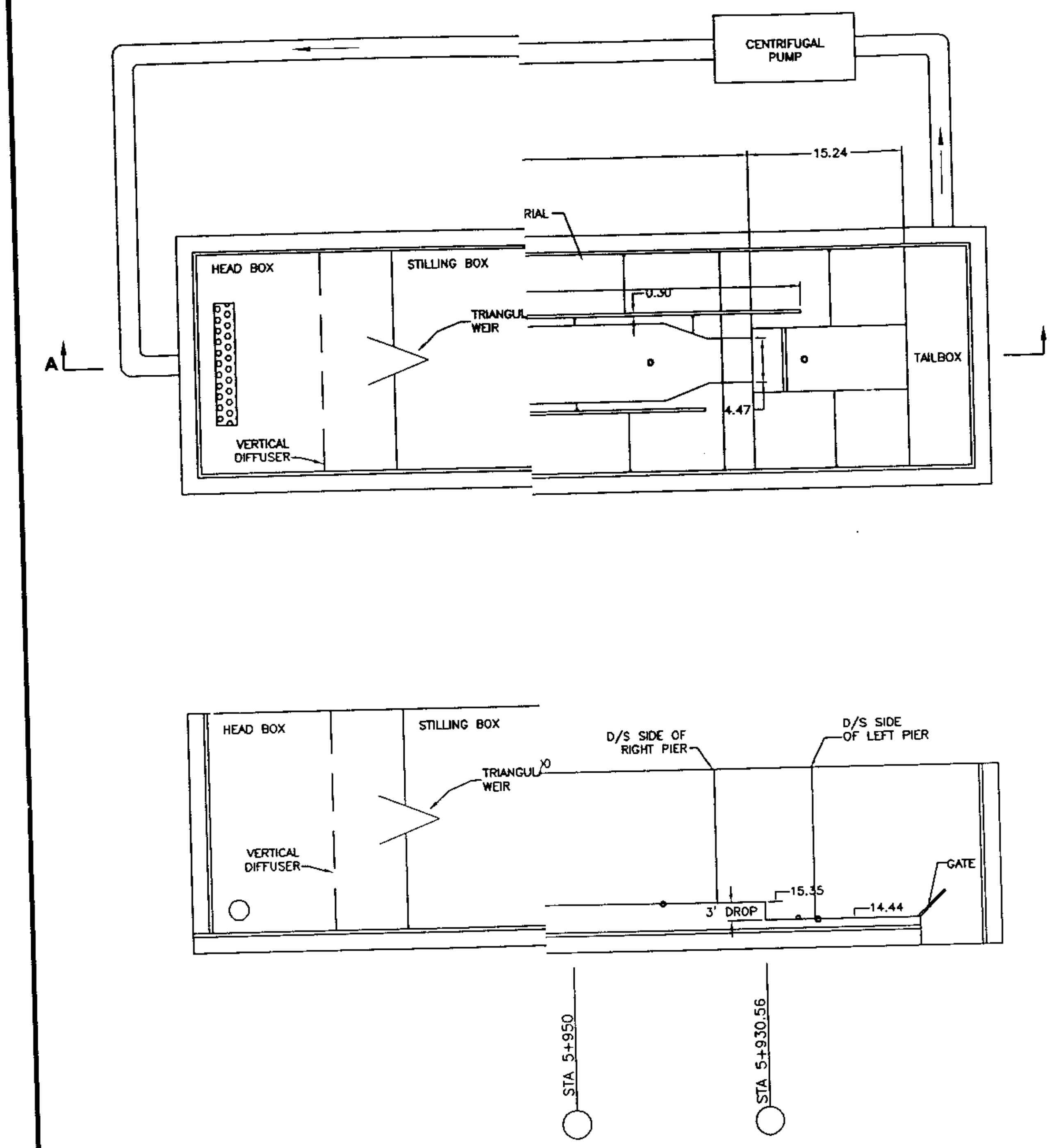
FIGURE 1-4



NOTES
1) DIMENSIONS GIVEN IN PROTOTYPE METERS.
2) MODEL SCALE: 1:18.
3) ○DENOTES LOCATION OF PRESSURE TAPS.
4) BASIN CONSTRUCTION TOLERANCES ±0.2 cm
HEADBOX CONSTRUCTION TOLERANCES ±0.5 cm
DROP STRUCTURE CONSTRUCTION TOLERANCES ±0.2 cm
5) CROSS SECTION DETAILS, SEE FIGURE 1-4

SANTA CLARA VALLEY WATER DISTRICT
STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Model Layout
Plan and Elevation View

3733-003	REV. NO. 0	Nov 5 2002

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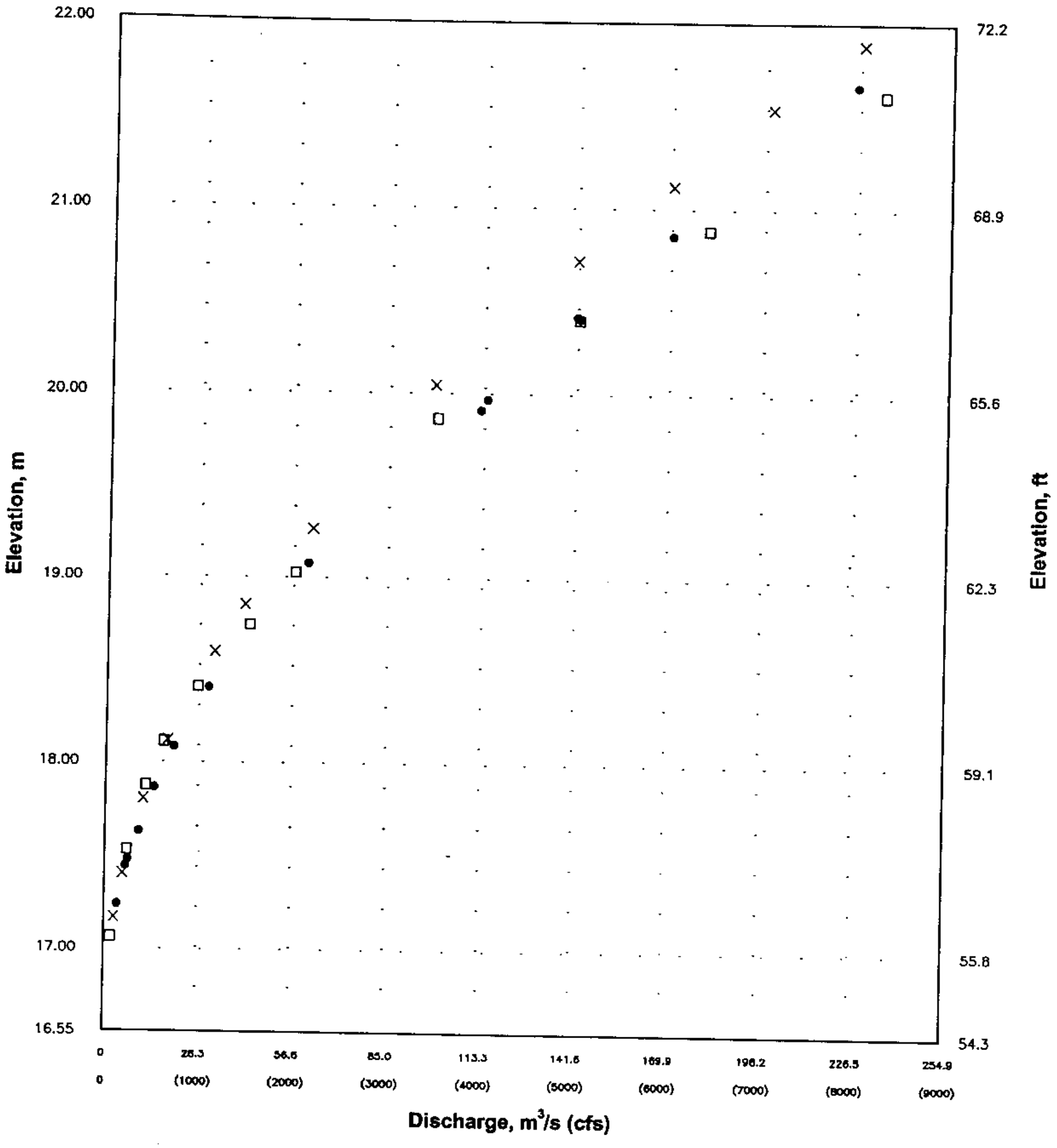
FIGURE 2-1



Legend – ● One layer of porous cloth in zig–zag configuration
– □ One layer of porous cloth in 'L' shape configuration
– × Modeled without vegetation

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Effect of Bnk Roughness on
Water-Level to Flow-Discharge Relationship
SCVWD Stream Gage 35

3733–015	REV. NO. 1	17/01/03

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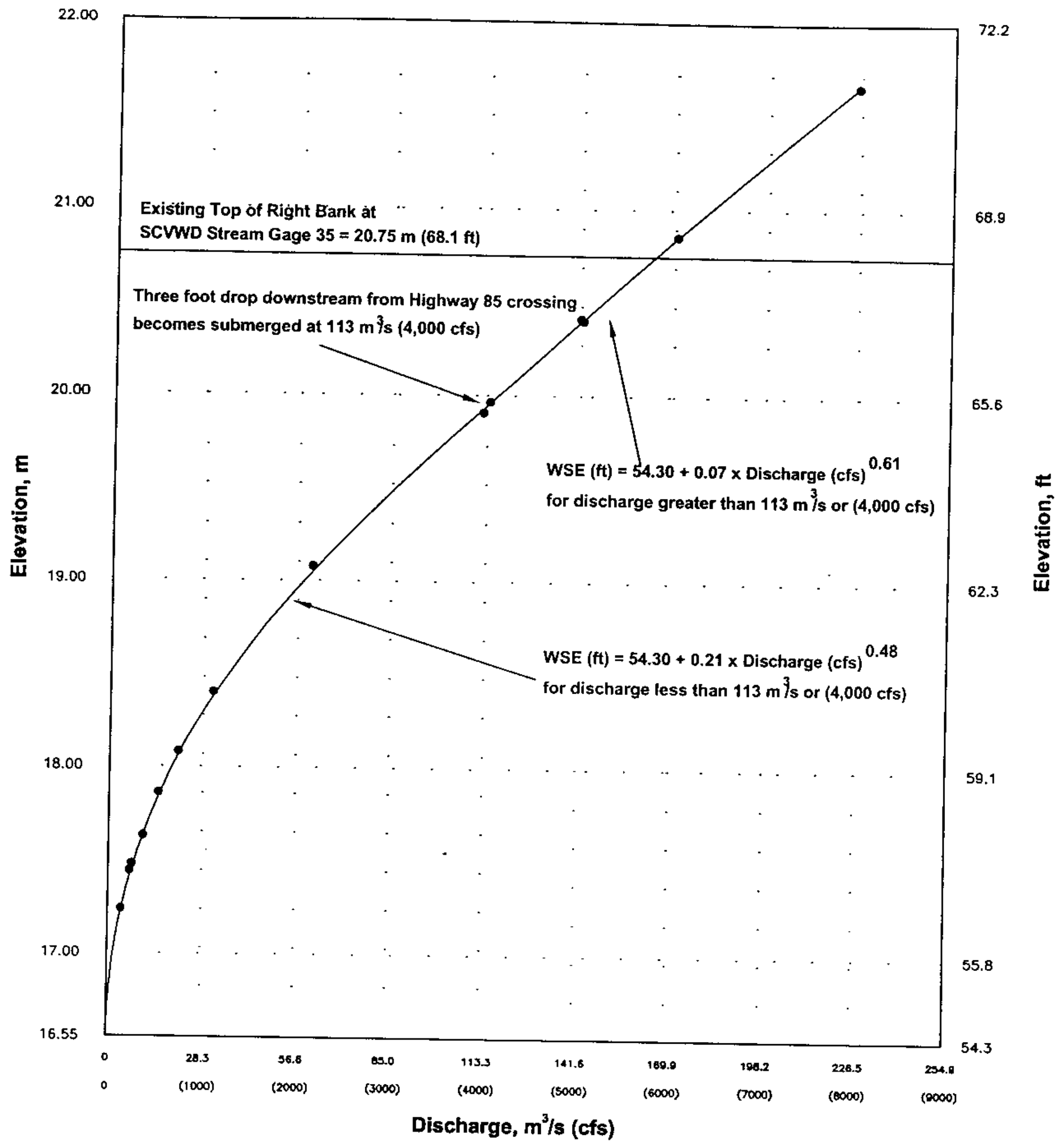
FIGURE 4-1



Legend – ● One layer of porous cloth in zig-zag configuration

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Water-Level to Flow-Discharge Relationship
SCVWD Stream Gage 35

3733-015	REV. NO. 1	17/01/03

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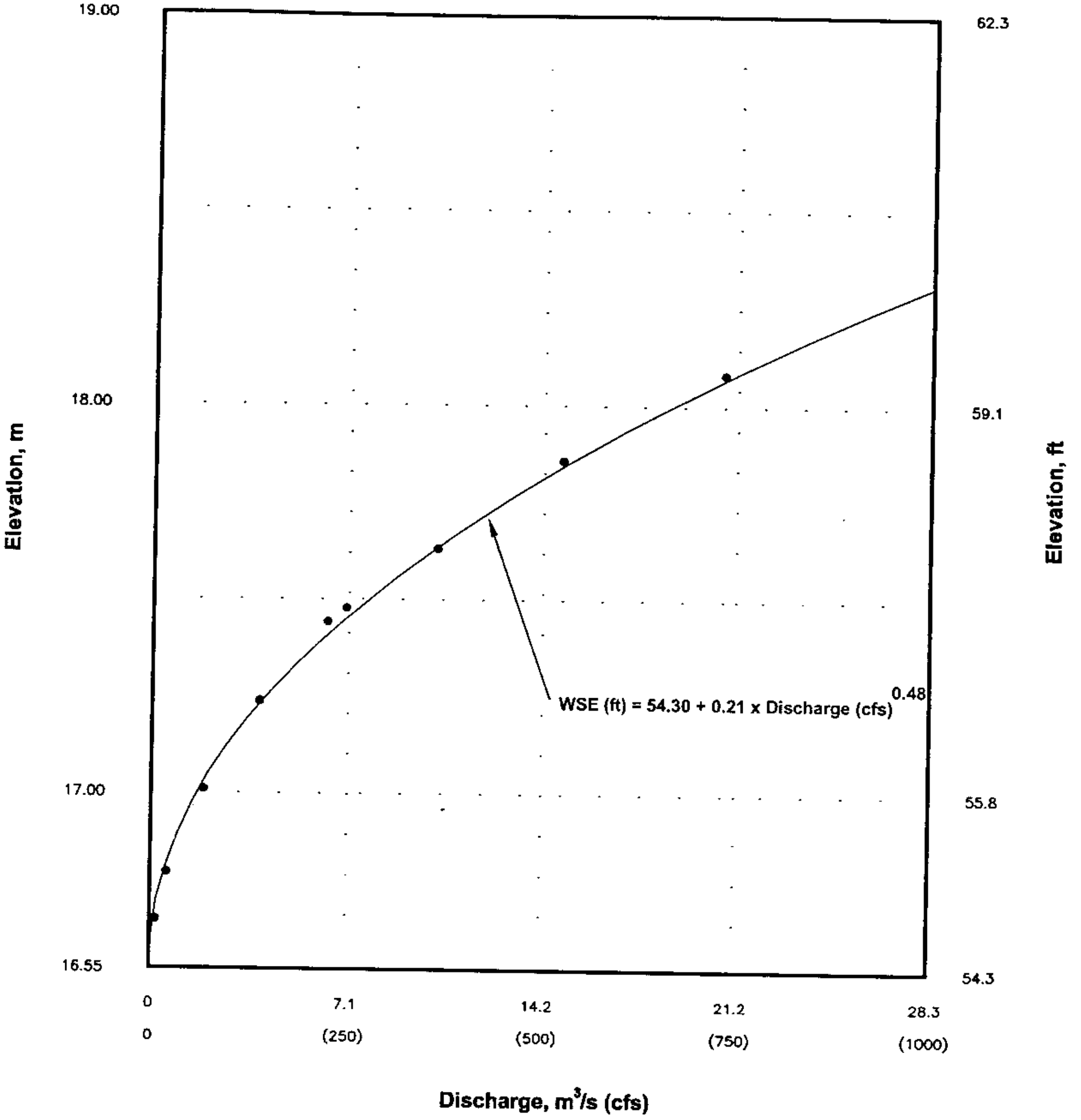
FIGURE 4-2



SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Water-Level to Flow-Discharge Relationship
Fish Migration Flow Conditions
SCVWD Stream Gage 35

3733-015	REV. NO. 1	17/01/03

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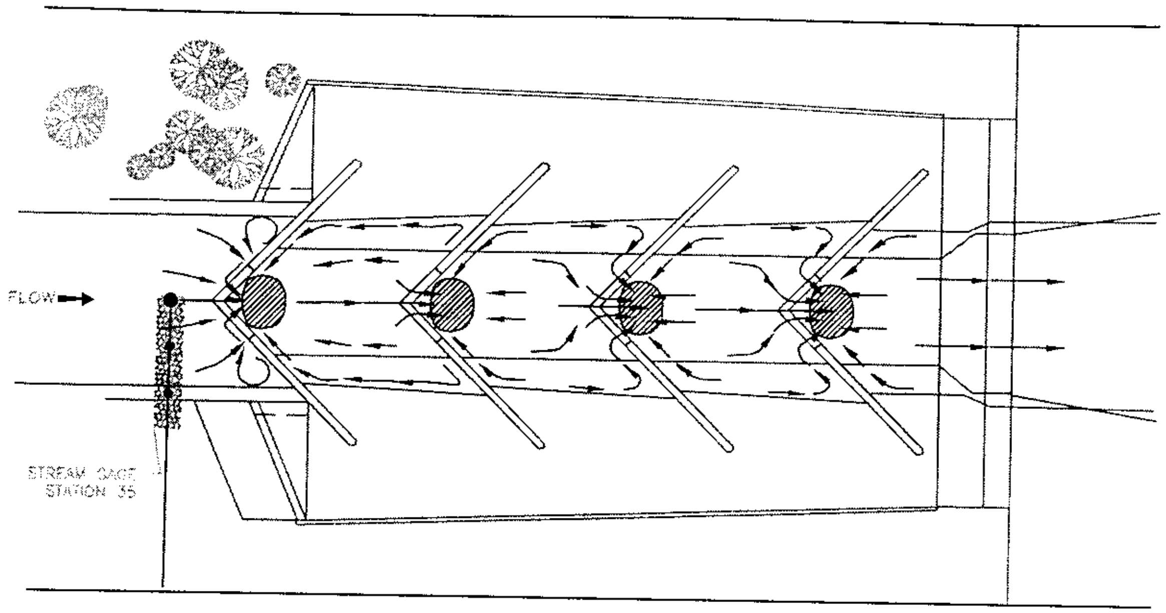
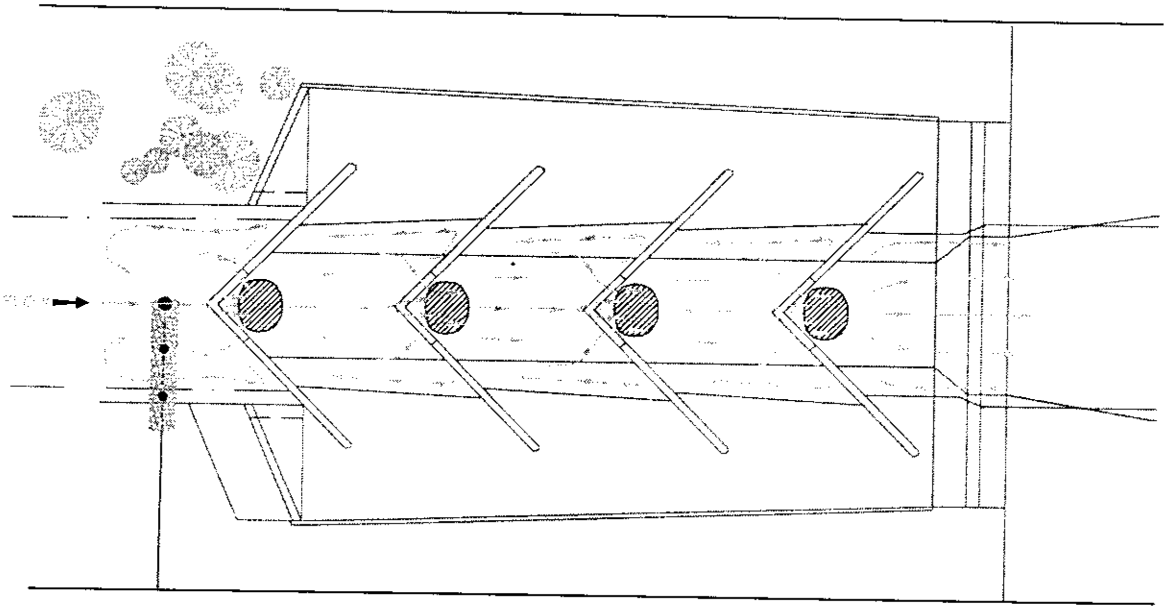
FIGURE 4-3



SURFACE FLOWS



SUB-SURFACE FLOWS

▨ PLUNGE ZONE

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Fish Migration Flow Patterns

Stevens Creek Discharge = 0.6 m^3/s (20 cfs)

3733-005 | REV. NO. 0 | 01/21/03

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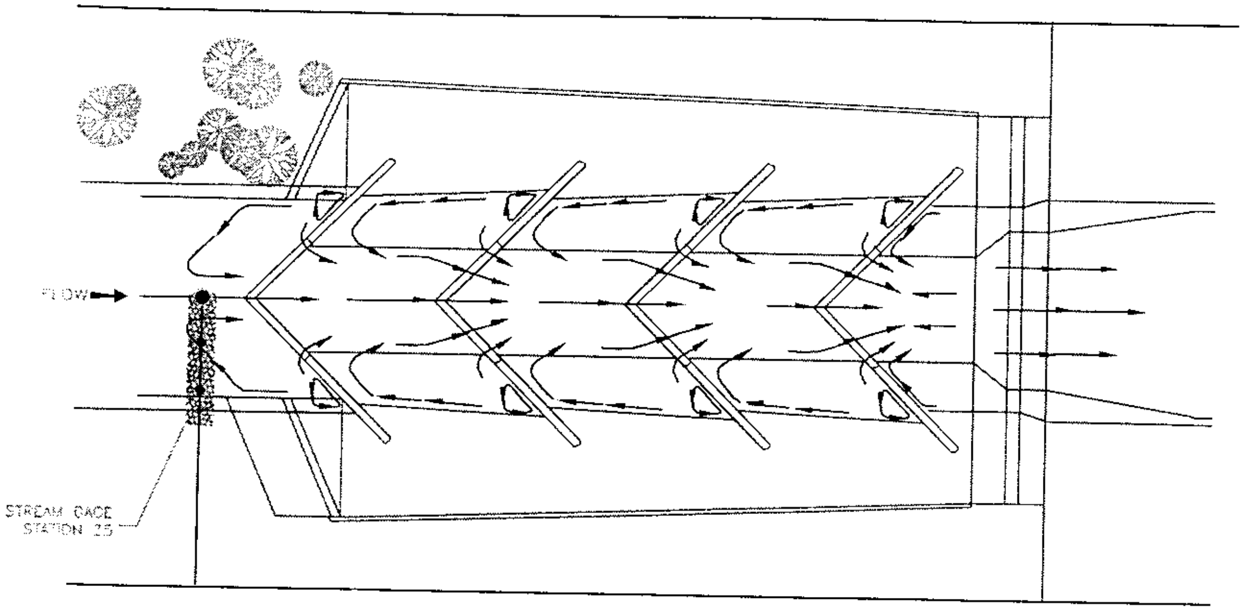
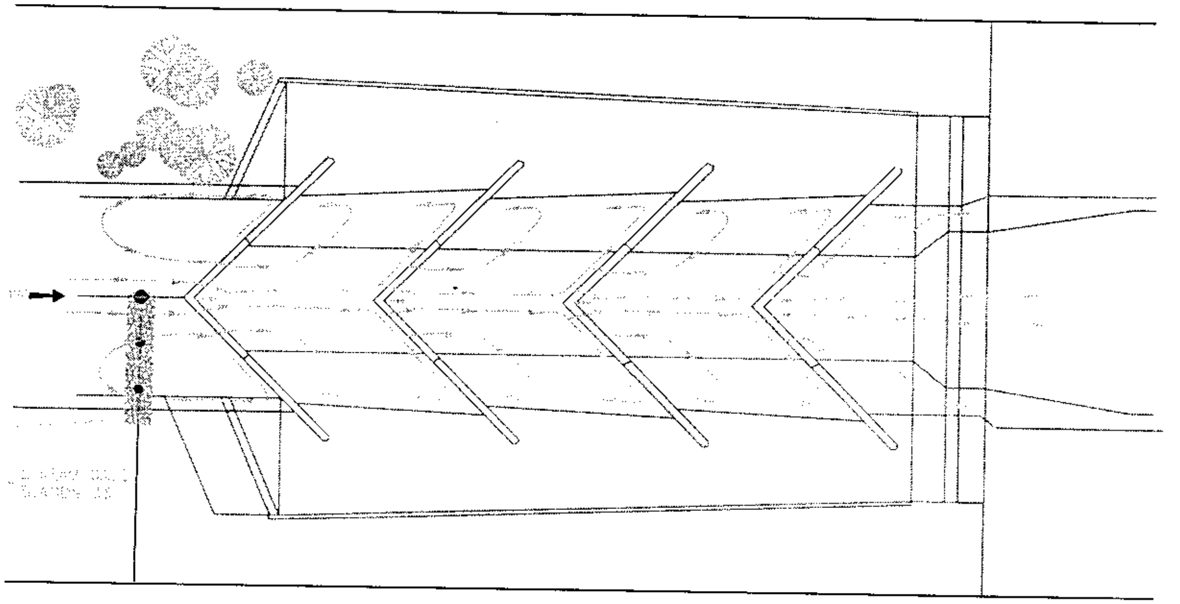
Figure 4-4



SURFACE FLOWS



SUB-SURFACE FLOWS

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Fish Migration Flow Patterns

Stevens Creek Discharge = 1.9 m^3/s (66 cfs)

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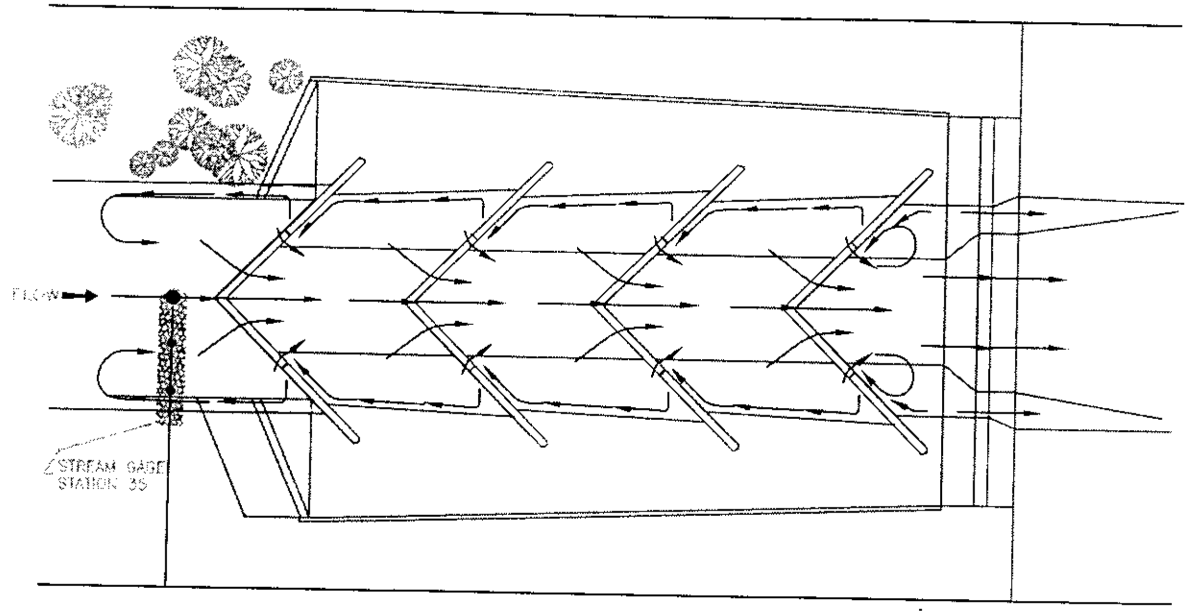
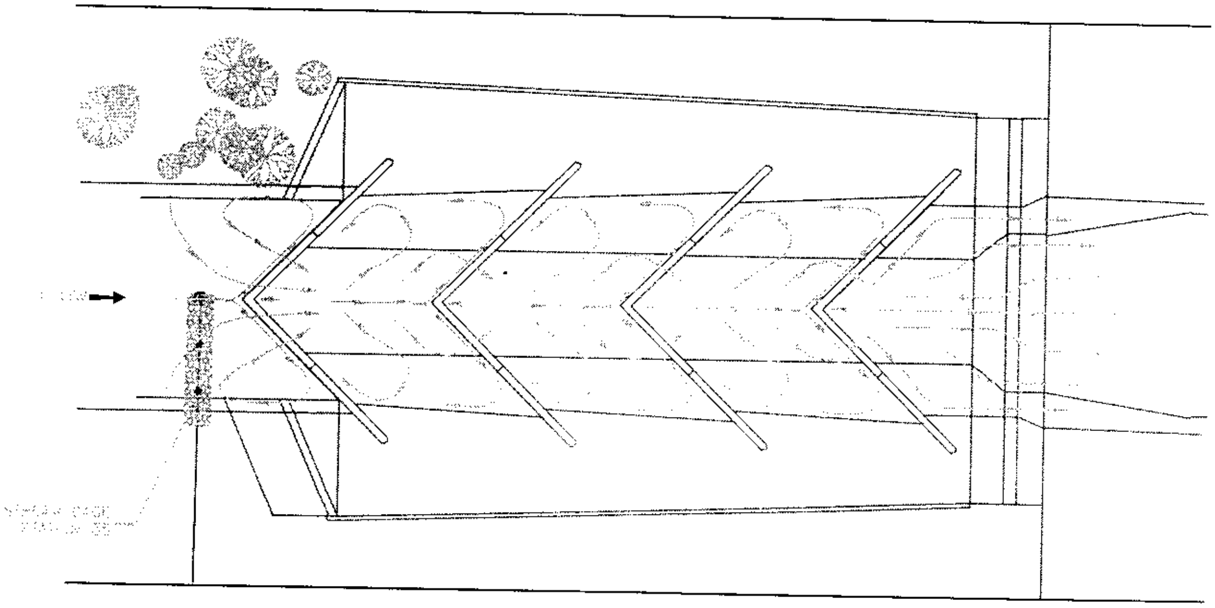
Figure 4-5



SURFACE FLOWS



SUB-SURFACE FLOWS

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Fish Migration Flow Patterns

Stevens Creek Discharge = 4.0 m^3/s (140 cfs)

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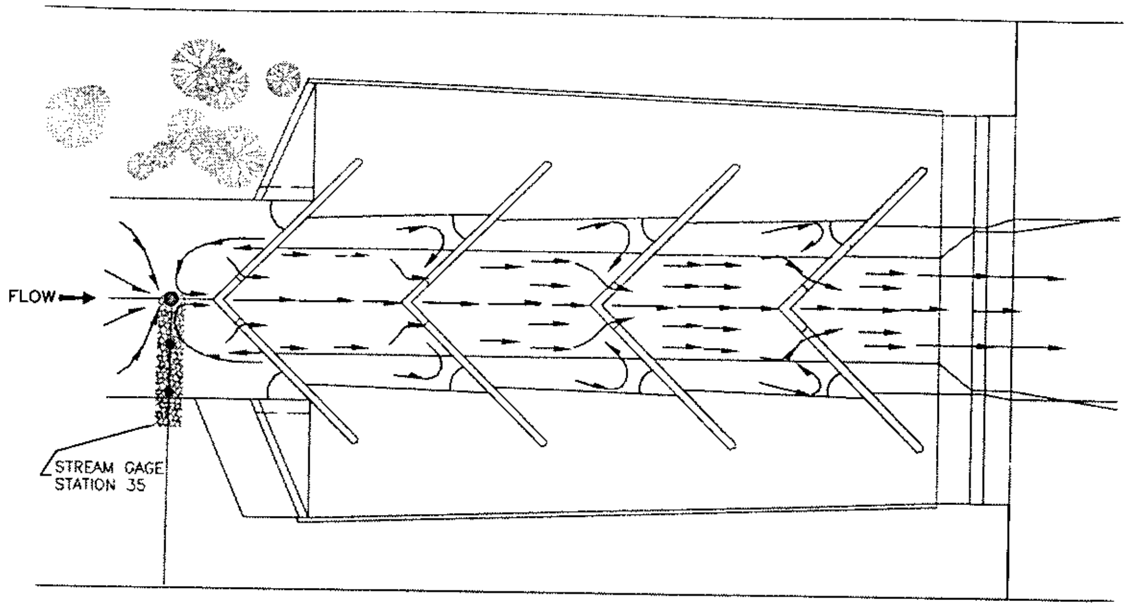
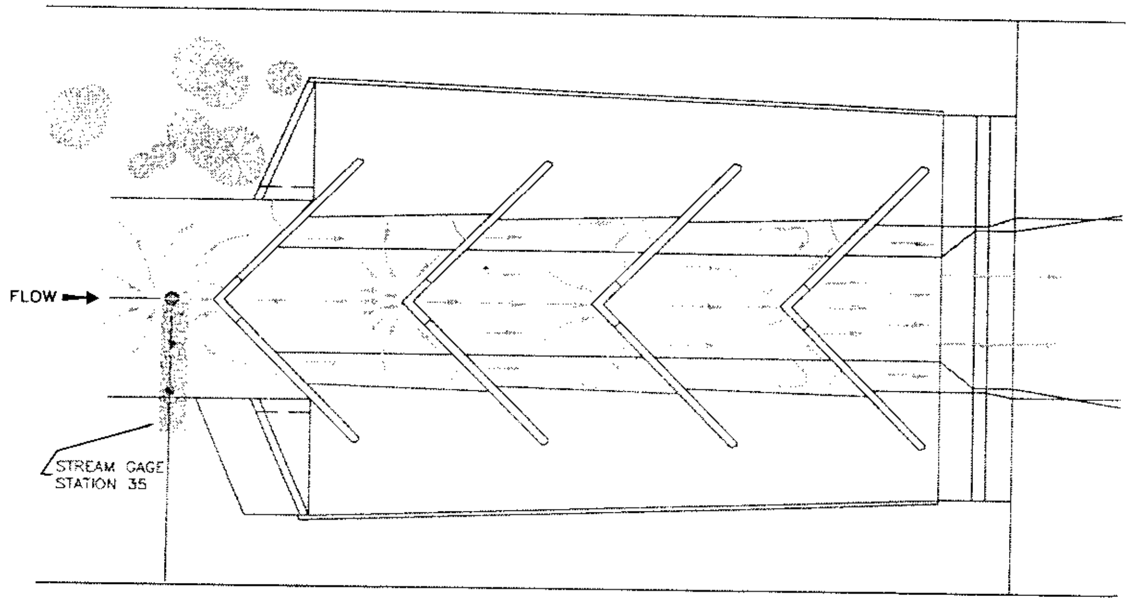
Figure 4-6



SURFACE FLOWS



SUB-SURFACE FLOWS

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Fish Migration Flow Patterns
with Deposited Sediment
Stevens Creek Discharge = 0.6 m^3/s (20 cfs)

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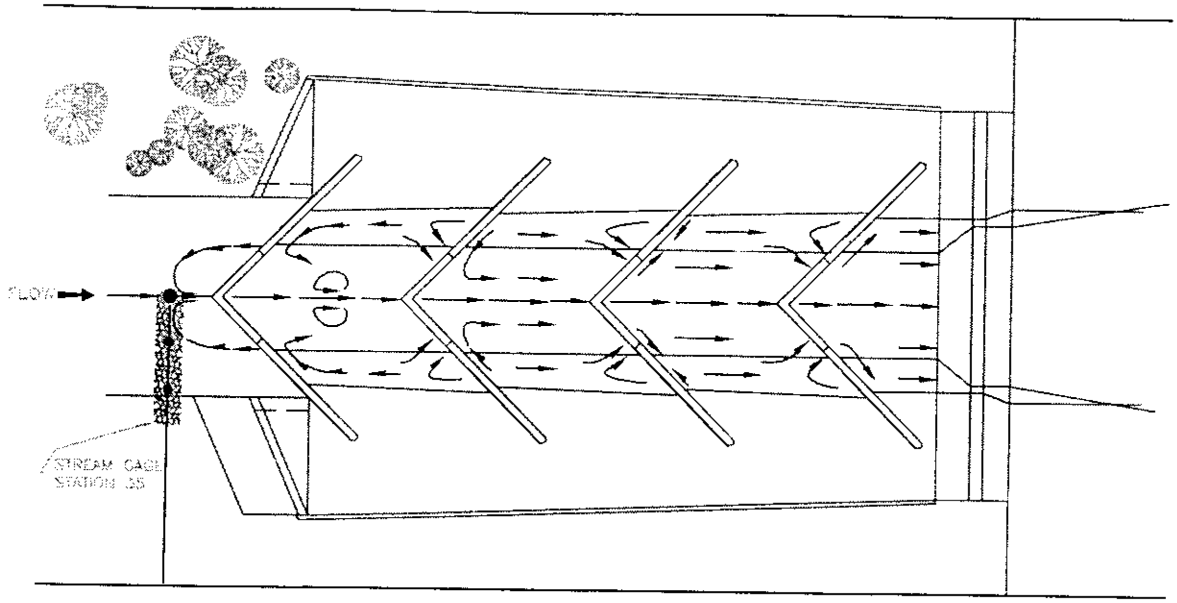
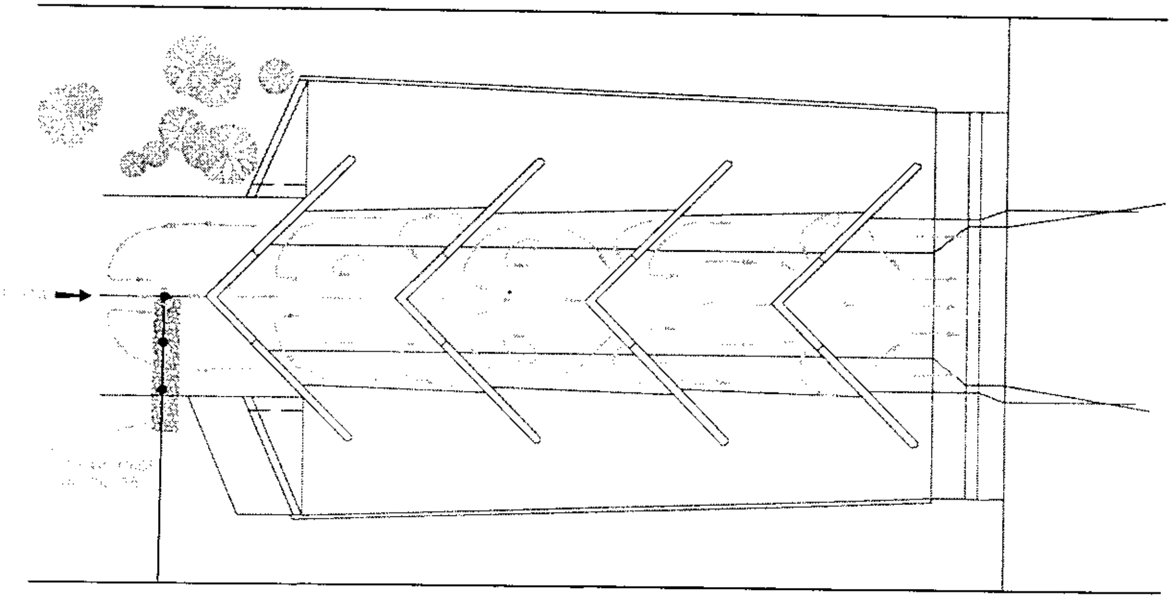
Figure 4-7



SURFACE FLOWS



SUB-SURFACE FLOWS

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Fish Migration Flow Patterns
with Deposited Sediment
Stevens Creek Discharge = 1.9 m^3/s (66 cfs)

3733–009	REV. NO.	0	01/21/03

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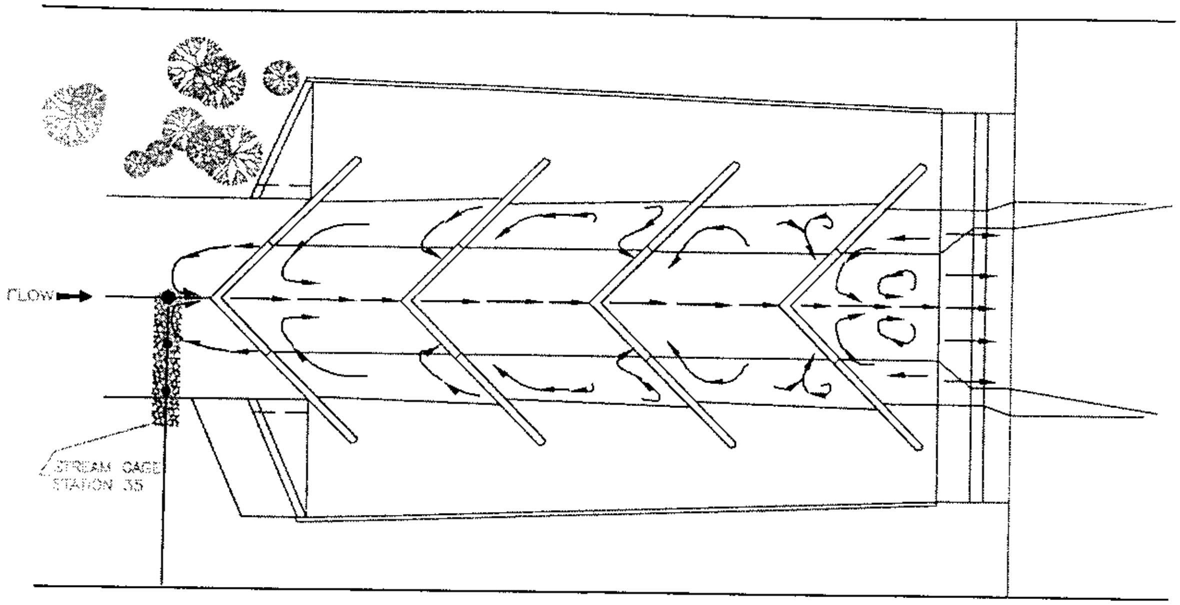
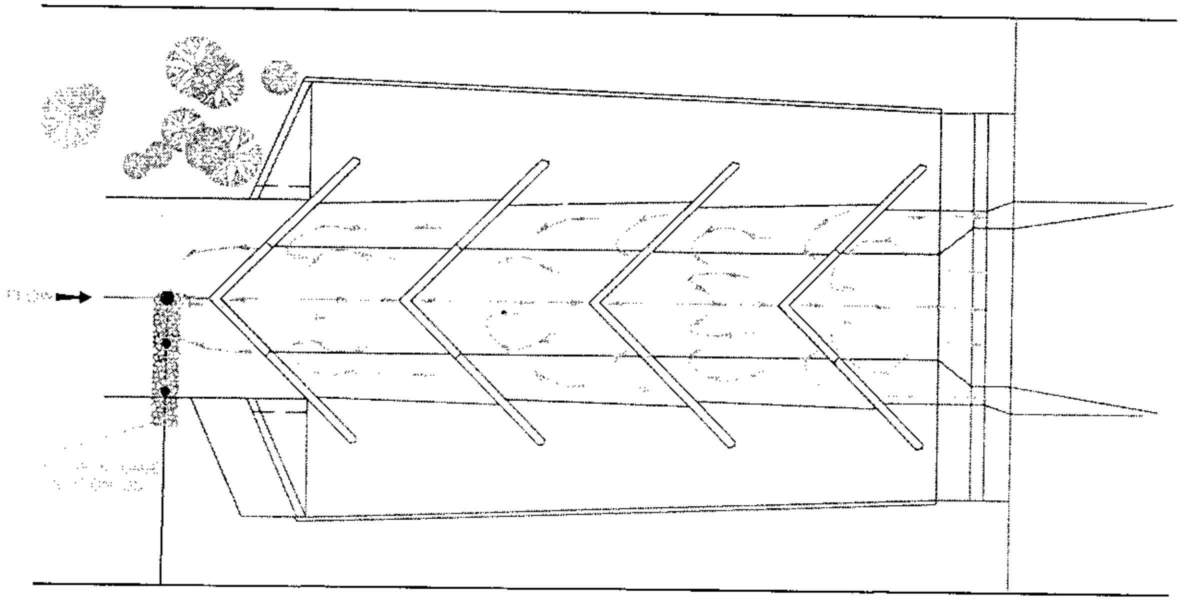
Figure 4-8



SURFACE FLOWS



SUB-SURFACE FLOWS

SANTA CLARA VALLEY WATER DISTRICT

STEVENS CREEK DROP STRUCTURE MODIFICATION
PHYSICAL HYDRAULIC MODEL STUDY

Fish Migration Flow Patterns
with Deposited Sediment
Stevens Creek Discharge = 4.0 m^3/s (140 cfs)

3733-010	REV. NO. 0	01/21/03

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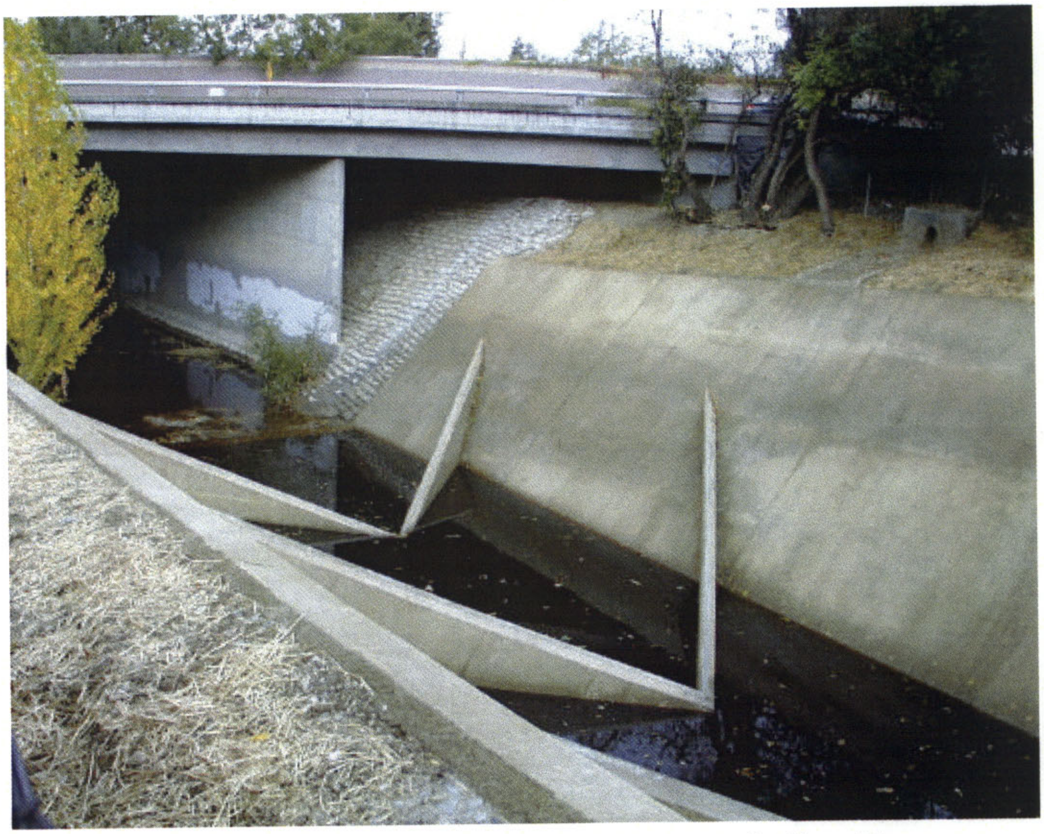
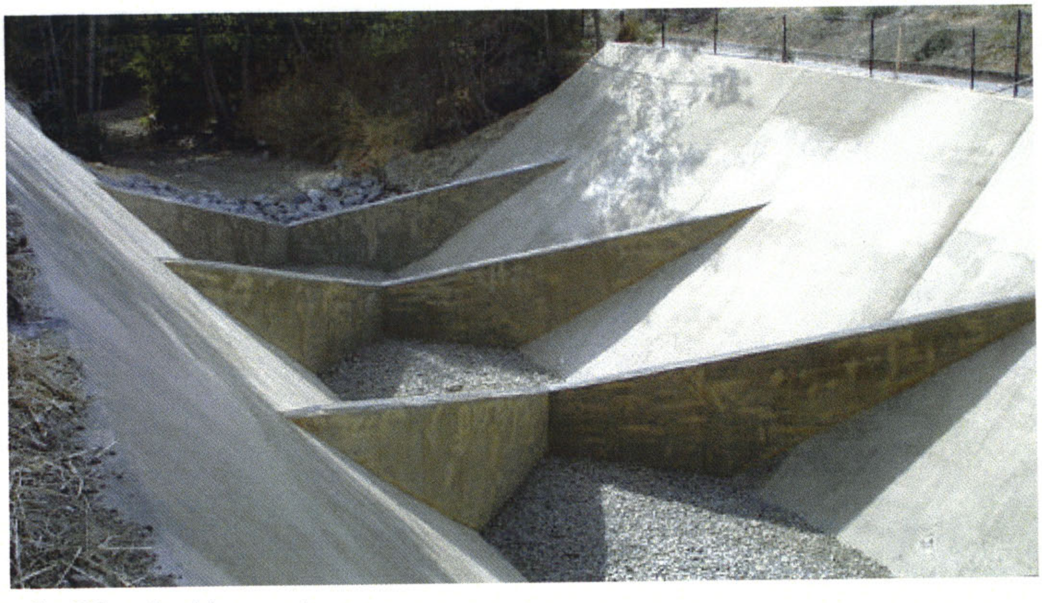
Figure 4-9



1) Oblique downstream view of the two downstream v-baffles. Note Highway 85 in the background.

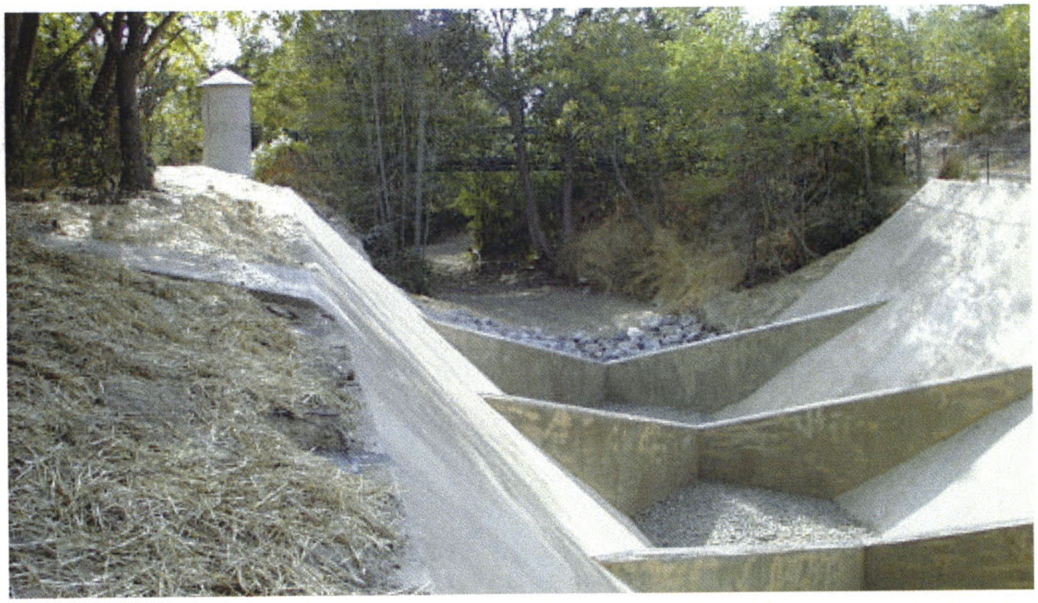


2) View looking upstream.

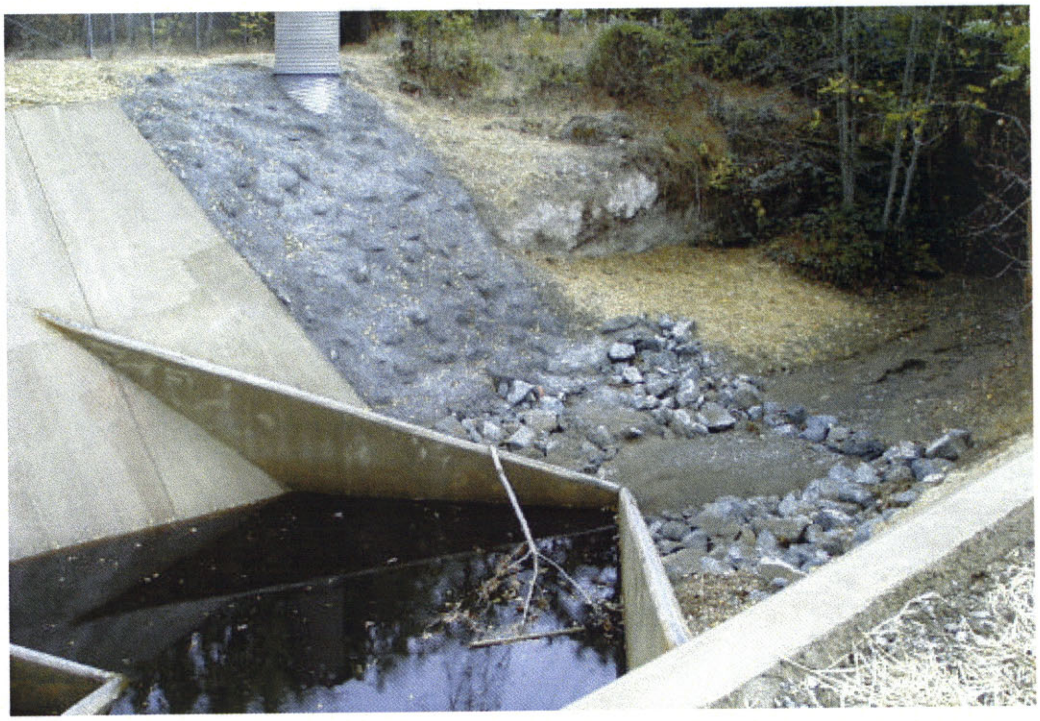
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

V-Baffle Drop Structure

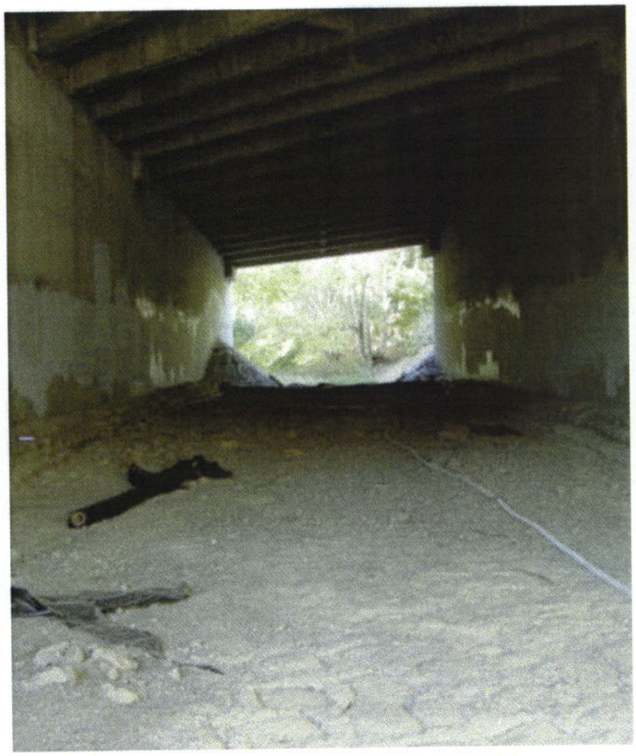
PHOTO PLATE 1-1



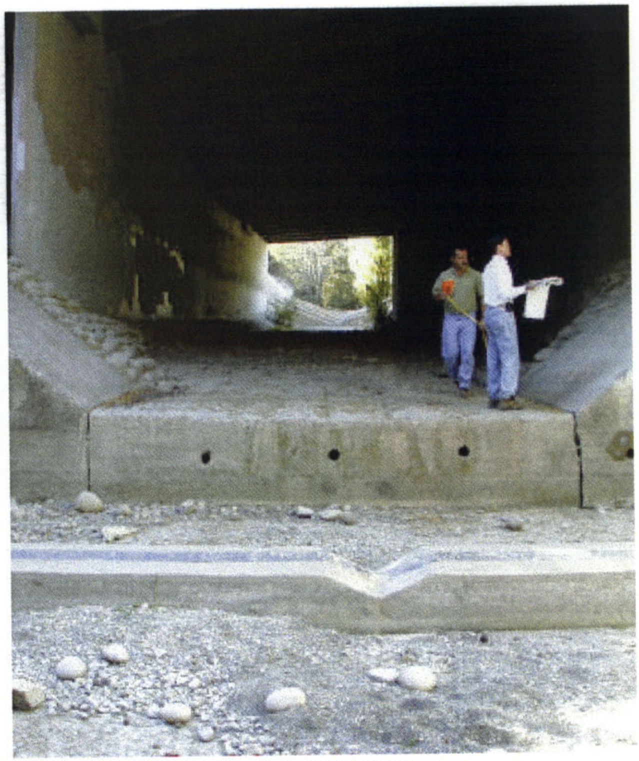
1) View looking upstream. Stream Gage Station 35 is shown on the right bank of the channel. Note the heavy vegetation on both banks upstream from the drop structure.



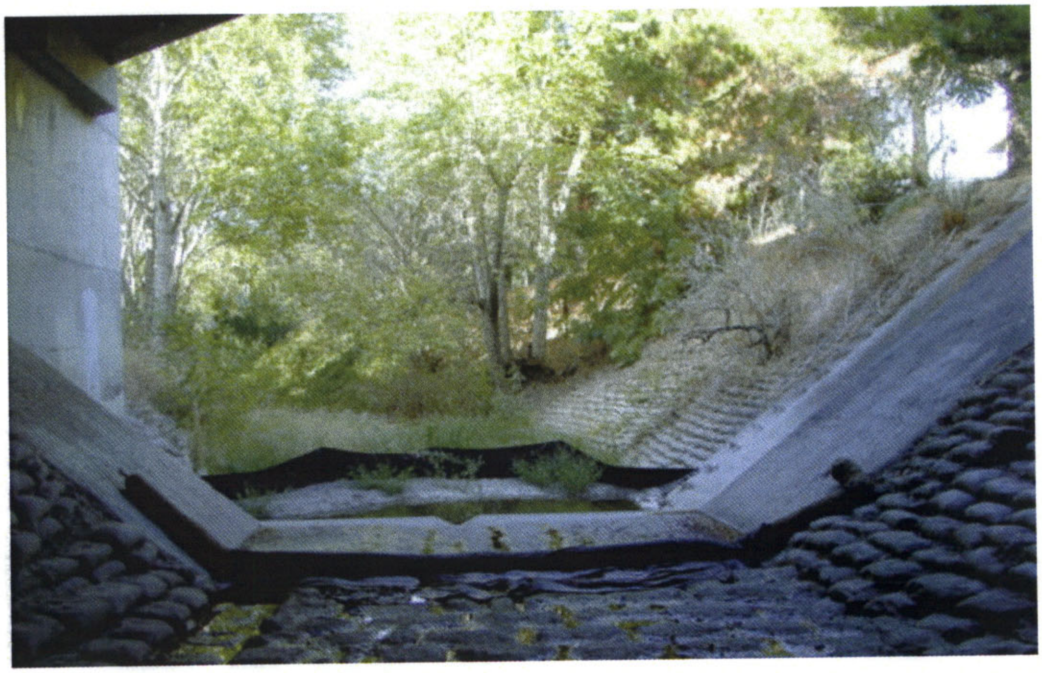
2) View looking upstream. Stream Gage Station 35 is shown on the right bank of the channel. The grouted right bank and riprap channel invert protect the communication pipes extending to the gage station.



2) View looking downstream under Highway 85. Note the concrete sack bed material.



1) View looking upstream toward the 3 foot vertical drop near the downstream end of the Highway 85 overpass.

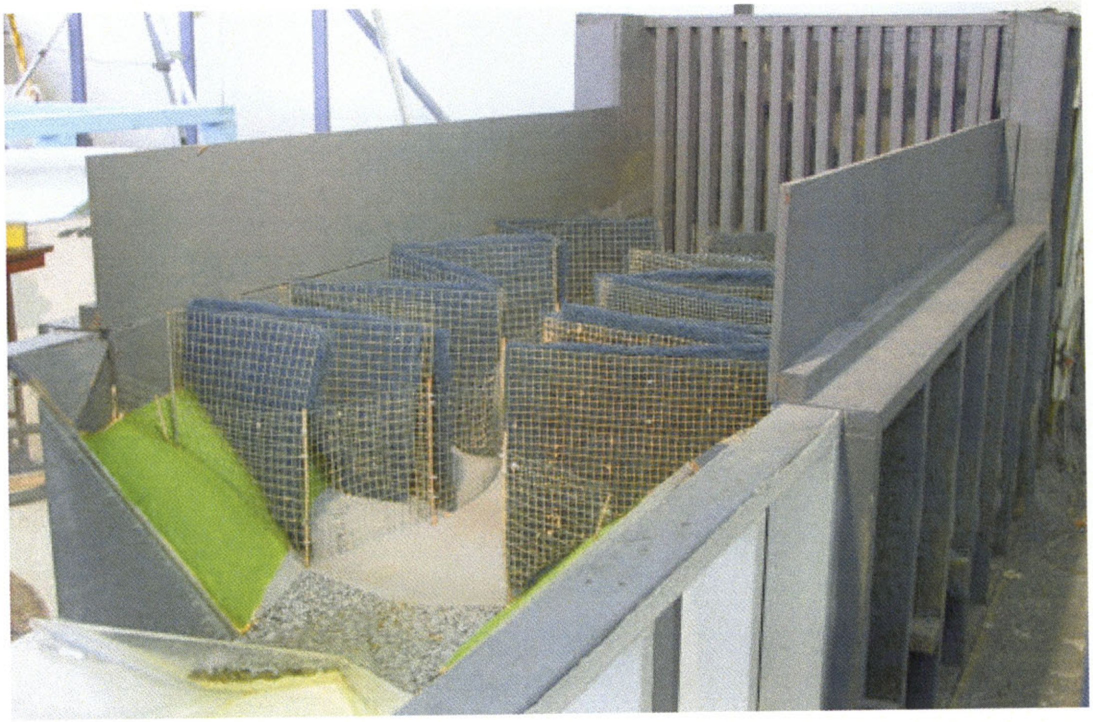


3) View from under the Highway 85 overpass looking downstream. Note the heavily vegetated banks are armored.

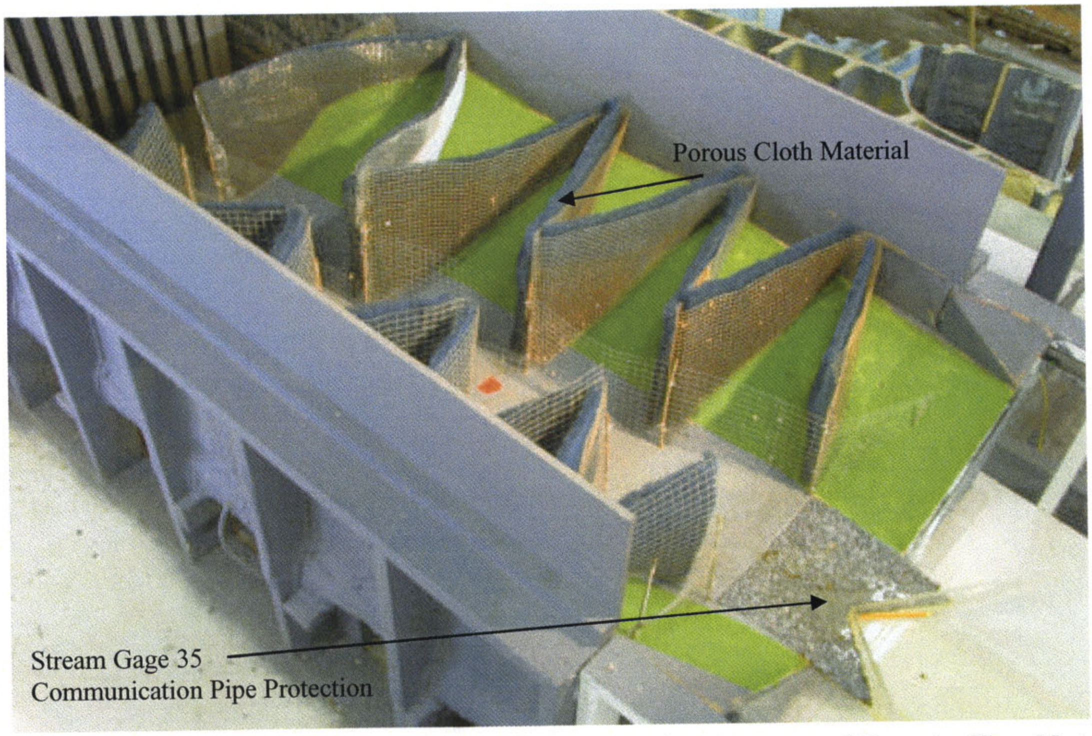
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Stevens Creek Channel Characteristics Downstream from the V-Baffle Drop Structure

PHOTO PLATE 1-3



1) View looking upstream toward the triangular weir box and topography upstream of Stream Gage 35.

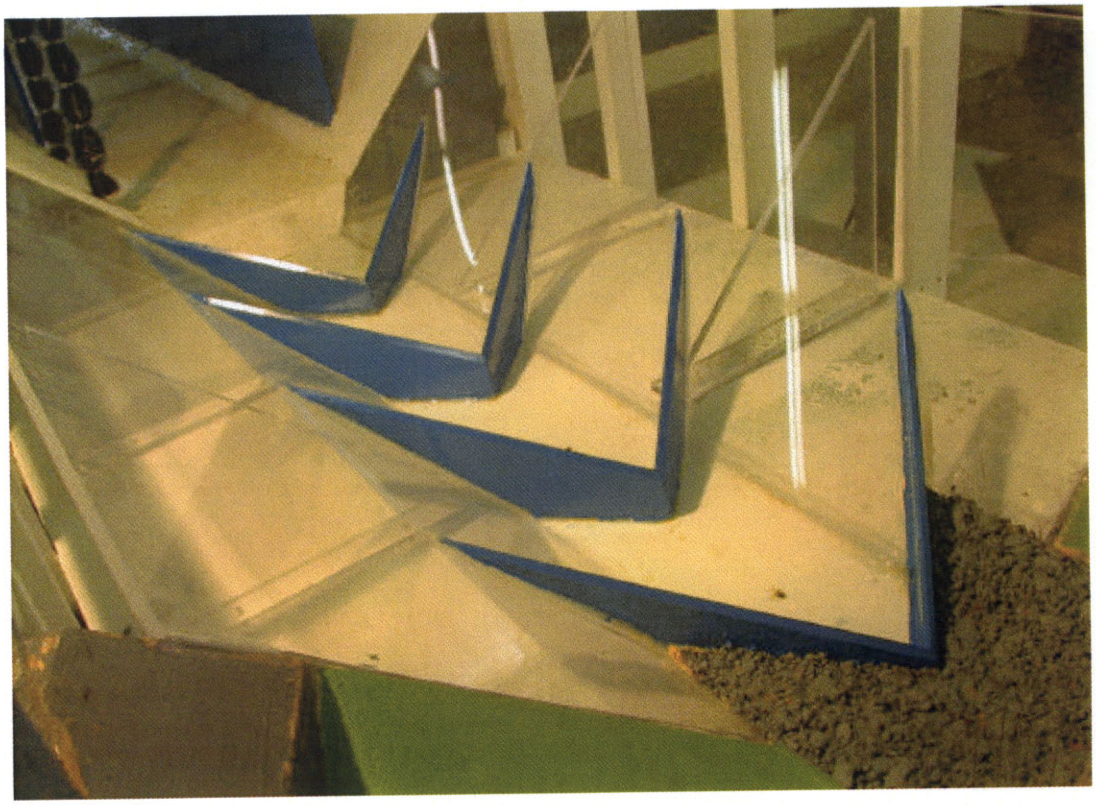


2) View looking upstream at the modeled topography upstream of the v-baffles. Note the porous cloth representing the vegetated banks upstream of Stream Gage 35.

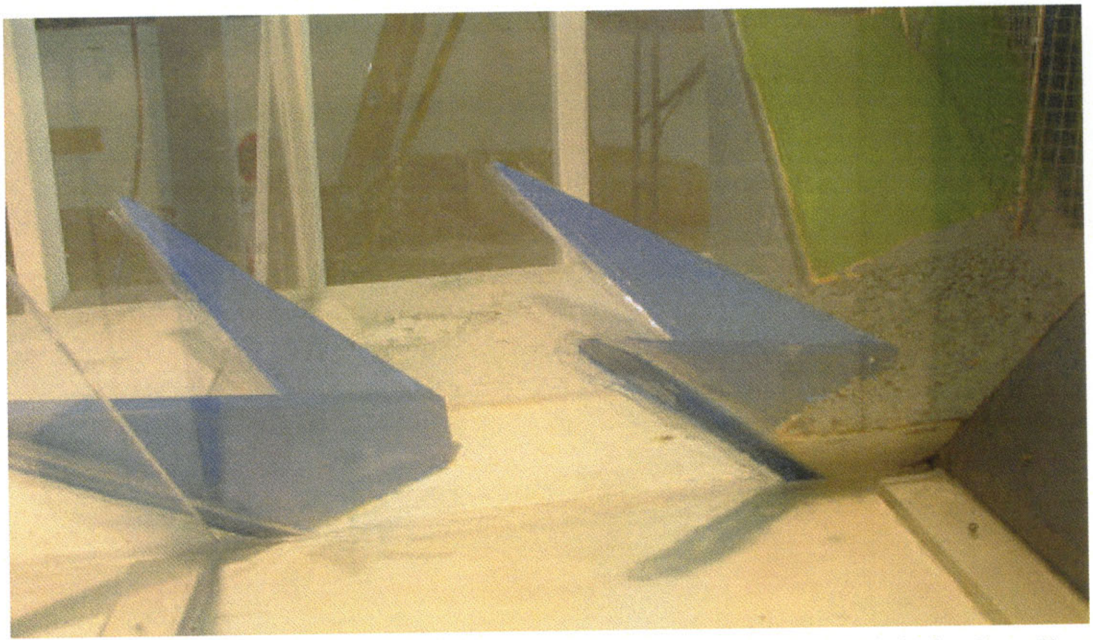
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Model Headworks and Topography Upstream of the Drop Structure

PHOTO PLATE 2-1



1) View looking downstream form above the left bank of Stream Gage 35.

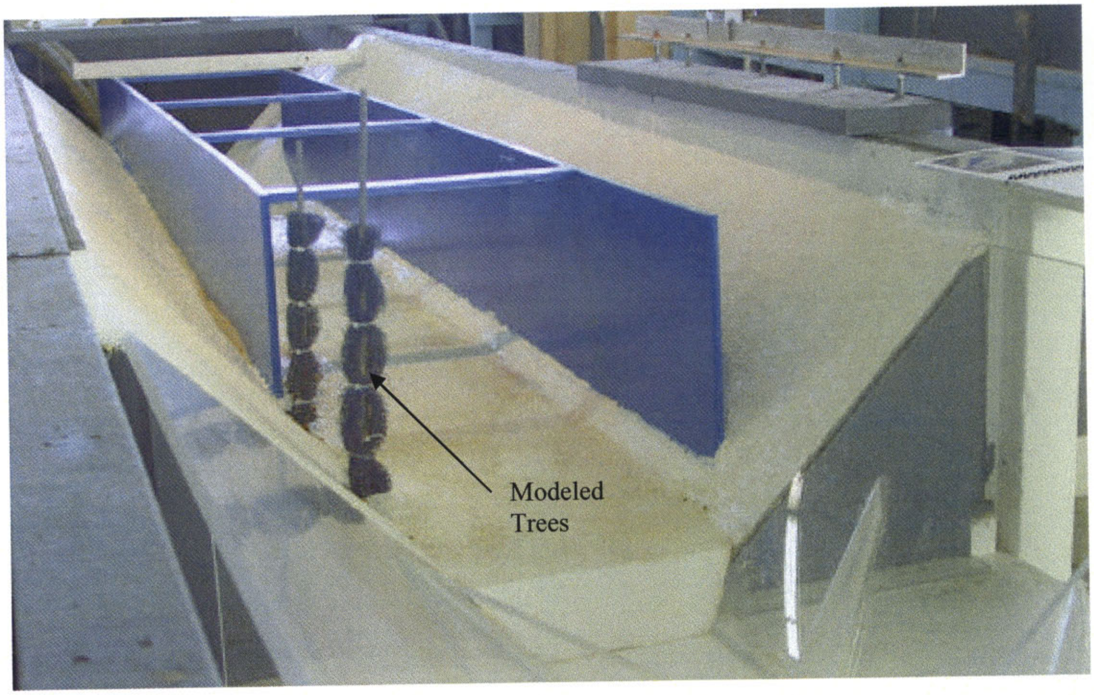


2) Side view of the two upstream v-baffles through the transparent right bank wall. Flow is from right to left.

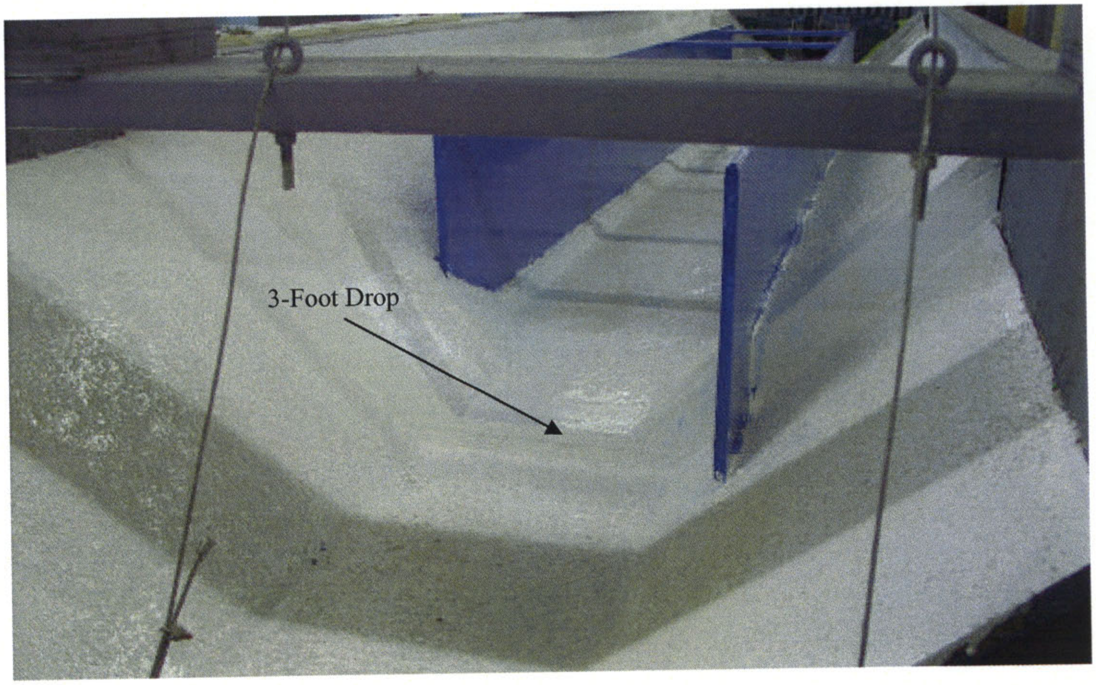
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Modeled V-Baffle Drop Structure

PHOTO PLATE 2-2



1) View looking downstream from above the left bank of the v-baffle drop structure. Note the porous cloth representing two trees.

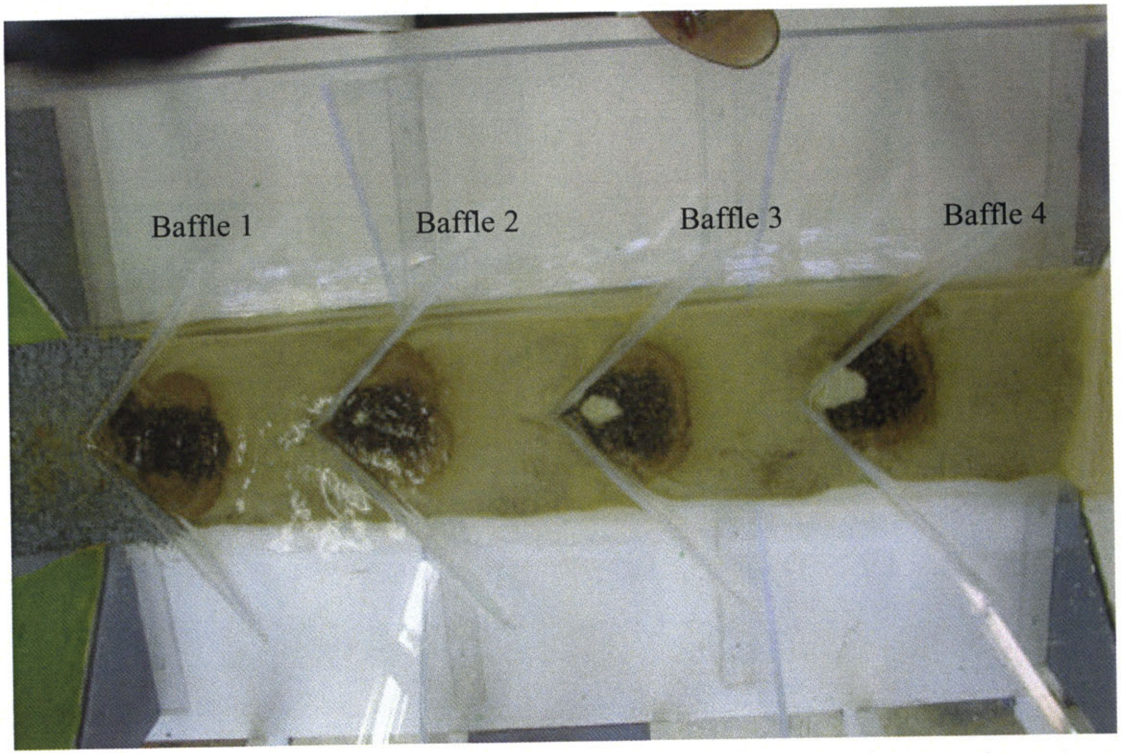


2) View looking upstream toward the 3-foot drop at Stream Gage 62.

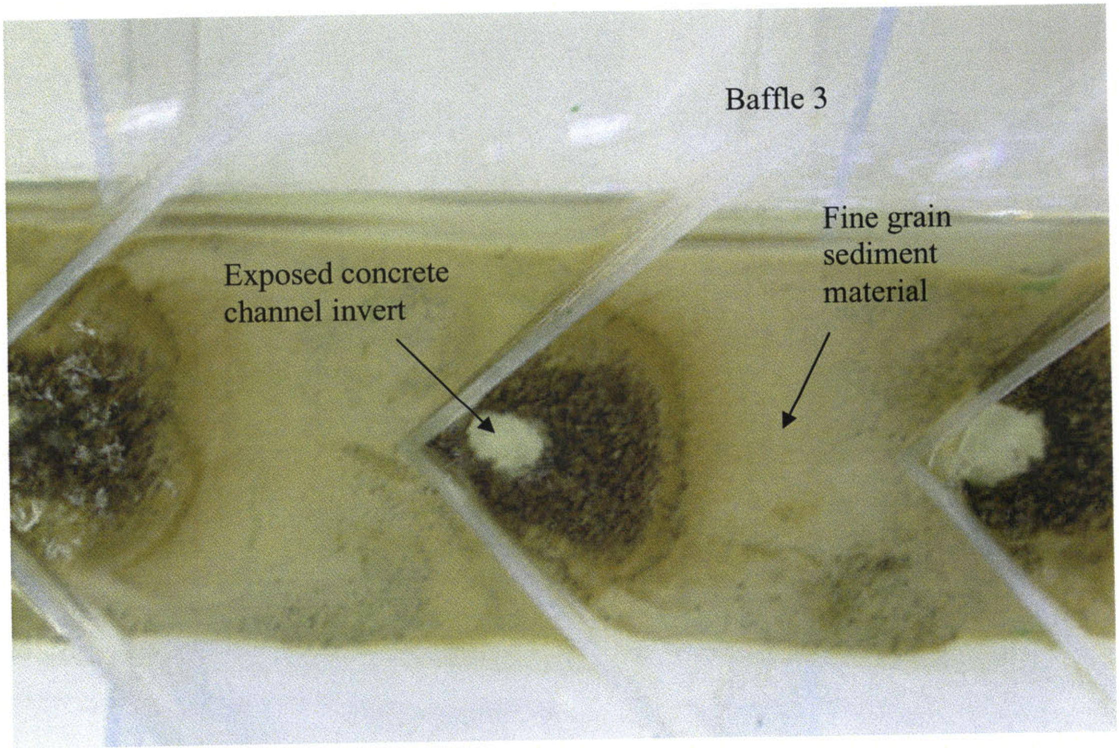
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Model Topography Downstream of the Drop Structure

PHOTO PLATE 2-3



1) View from above, flow is from left to right. Note the increase in scour downstream of Baffles 3 and 4.

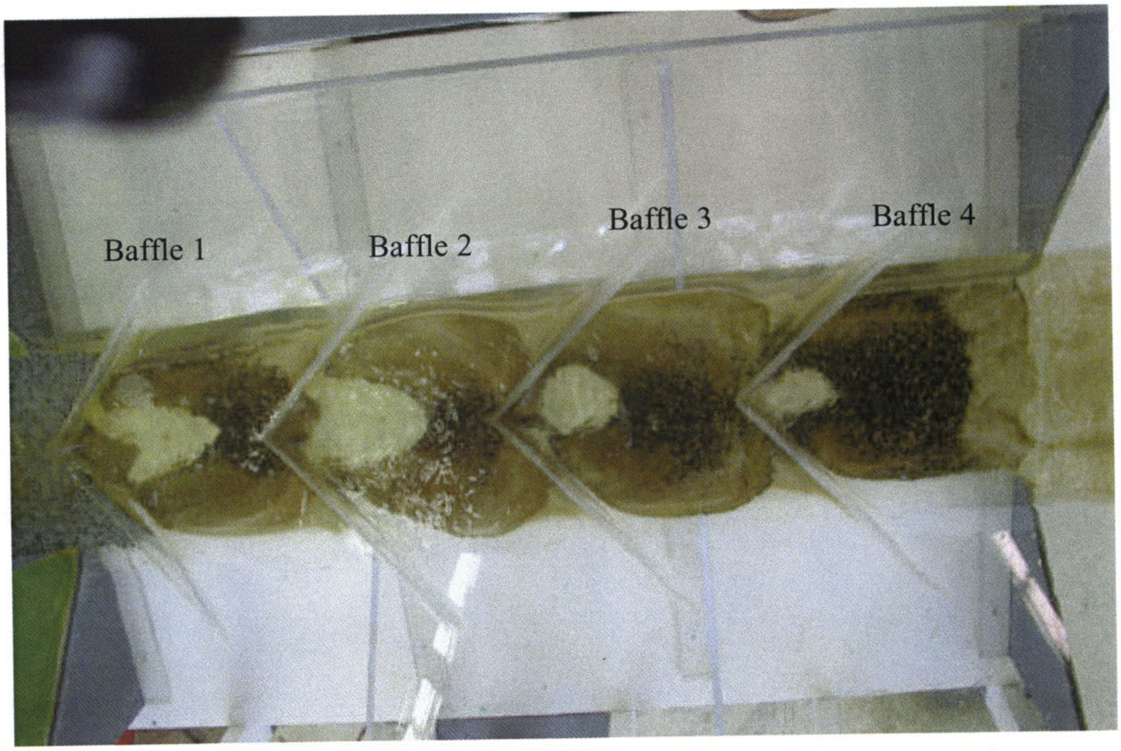


2) View from above Baffle 3.

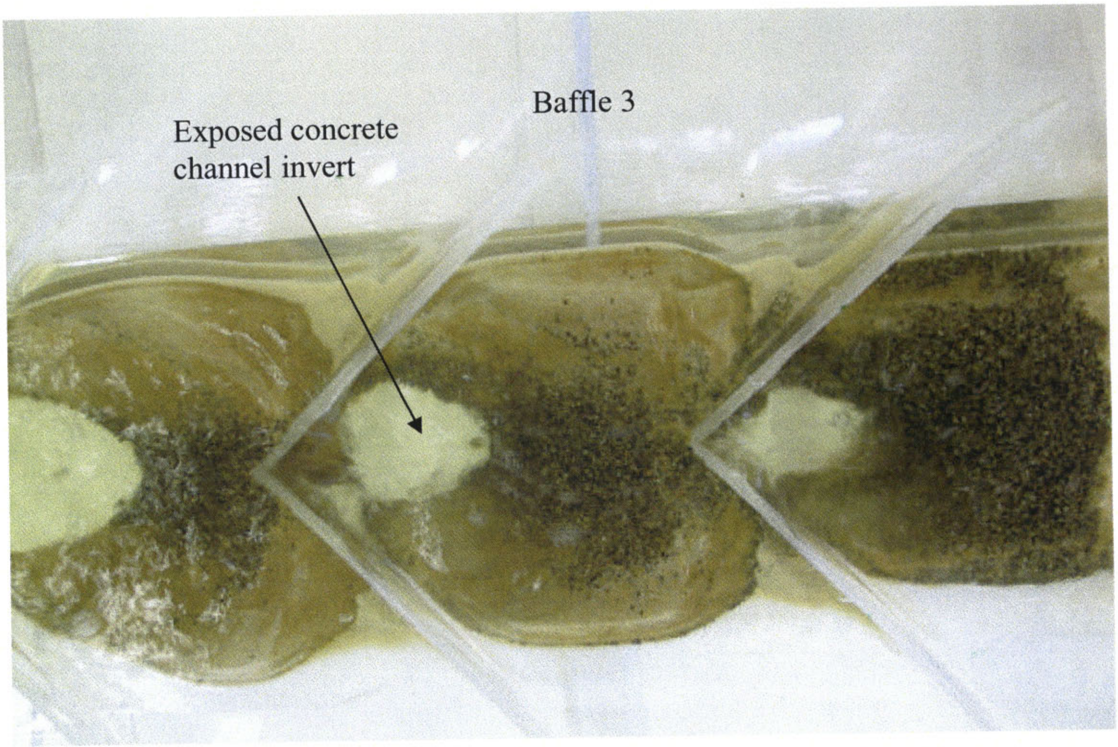
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Sediment Deposition - Stevens Creek Discharge = 20 cfs

PHOTO PLATE 4-1



1) View from above, flow is from left to right. Note the decrease in scour downstream of Baffles 3 and 4.

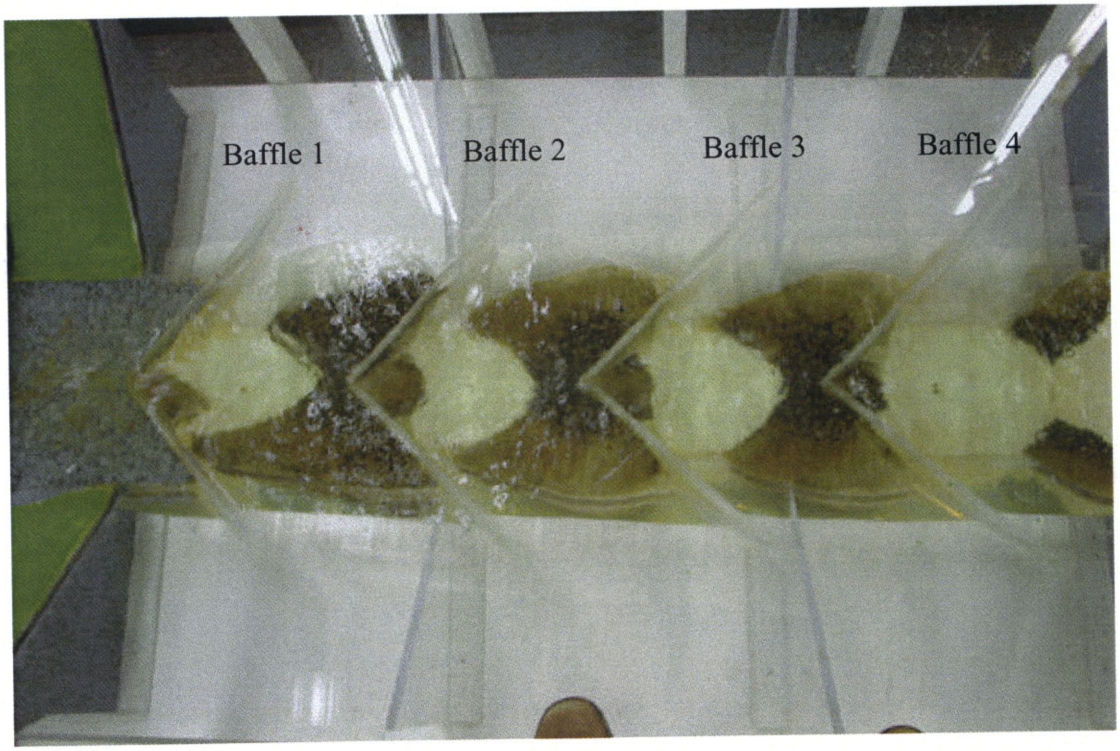


2) View from above Baffle 3.

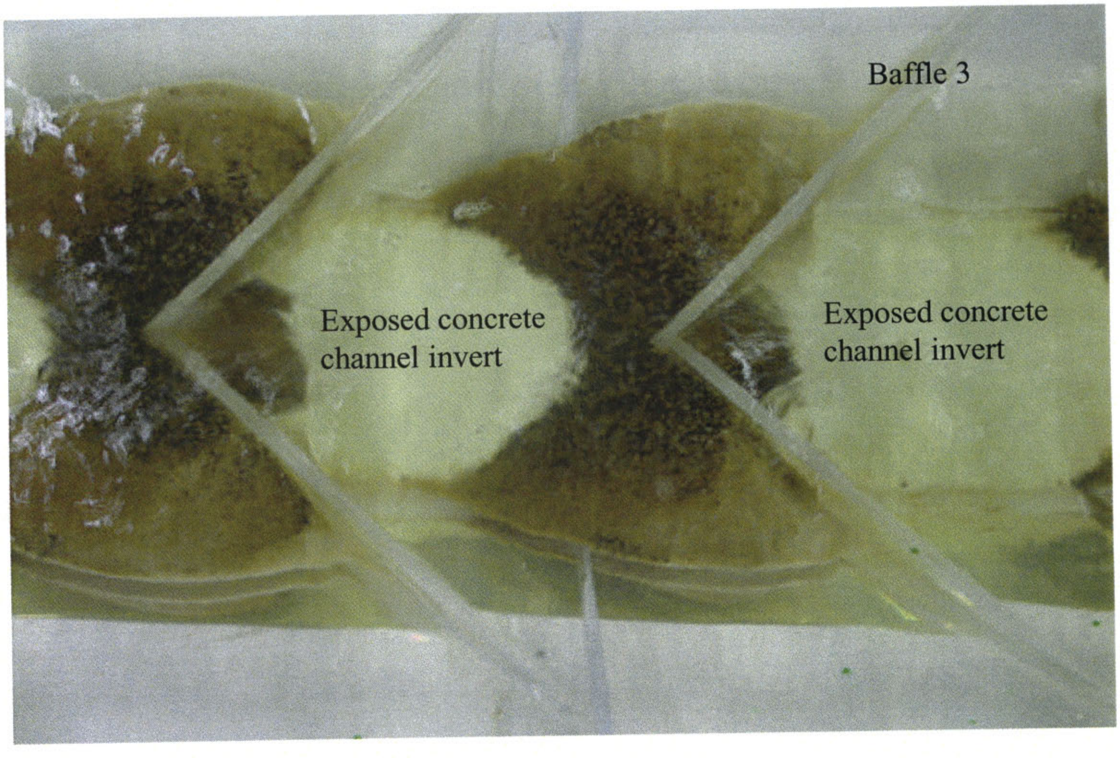
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Sediment Deposition - Stevens Creek Discharge = 66 cfs

PHOTO PLATE 4-2



1) View from above, flow is from left to right. Note the increase in scour downstream of Baffles 3 and 4.

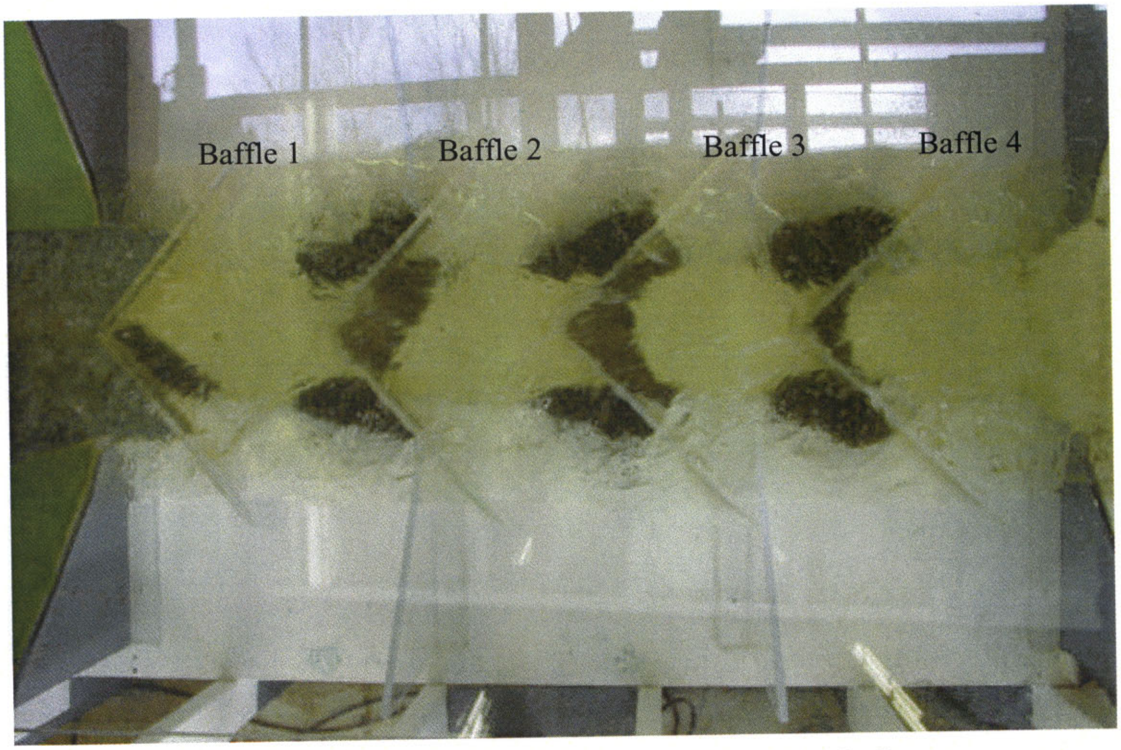

Baffle 3
Exposed concrete channel invert
Exposed concrete channel invert

2) View from above Baffle 3.

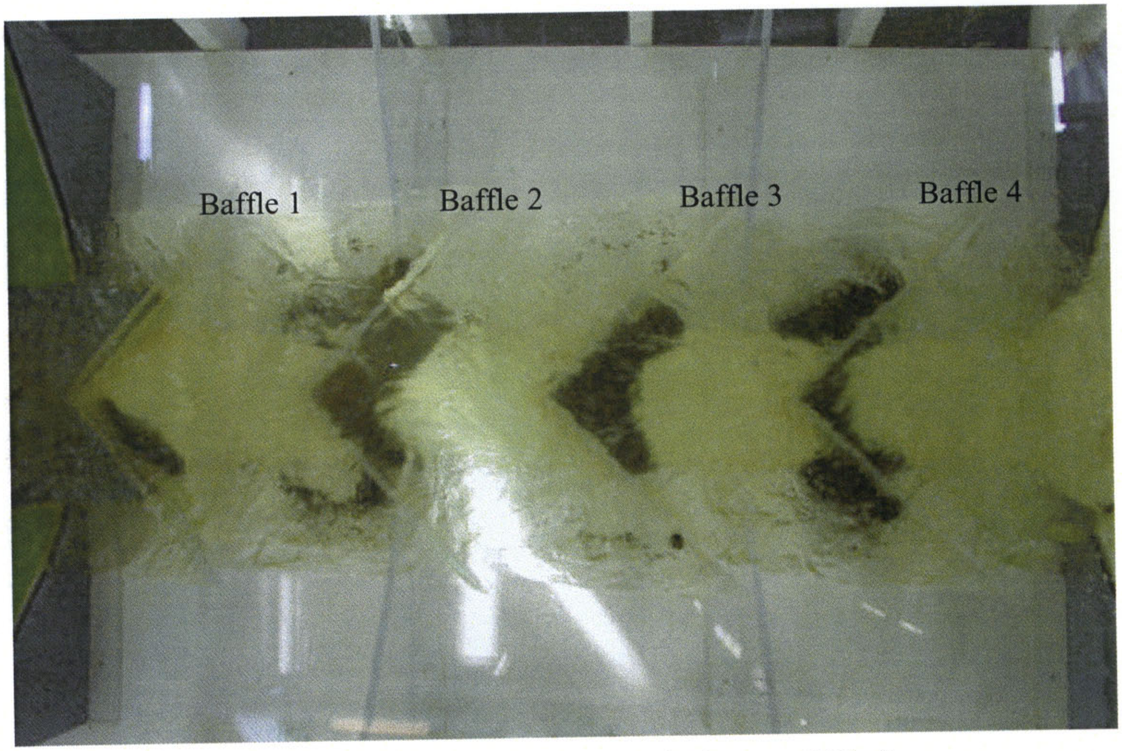
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Sediment Deposition - Stevens Creek Discharge = 140 cfs

PHOTO PLATE 4-3



1) Sediment deposition patterns. Stevens Creek Discharge = 600 cfs.

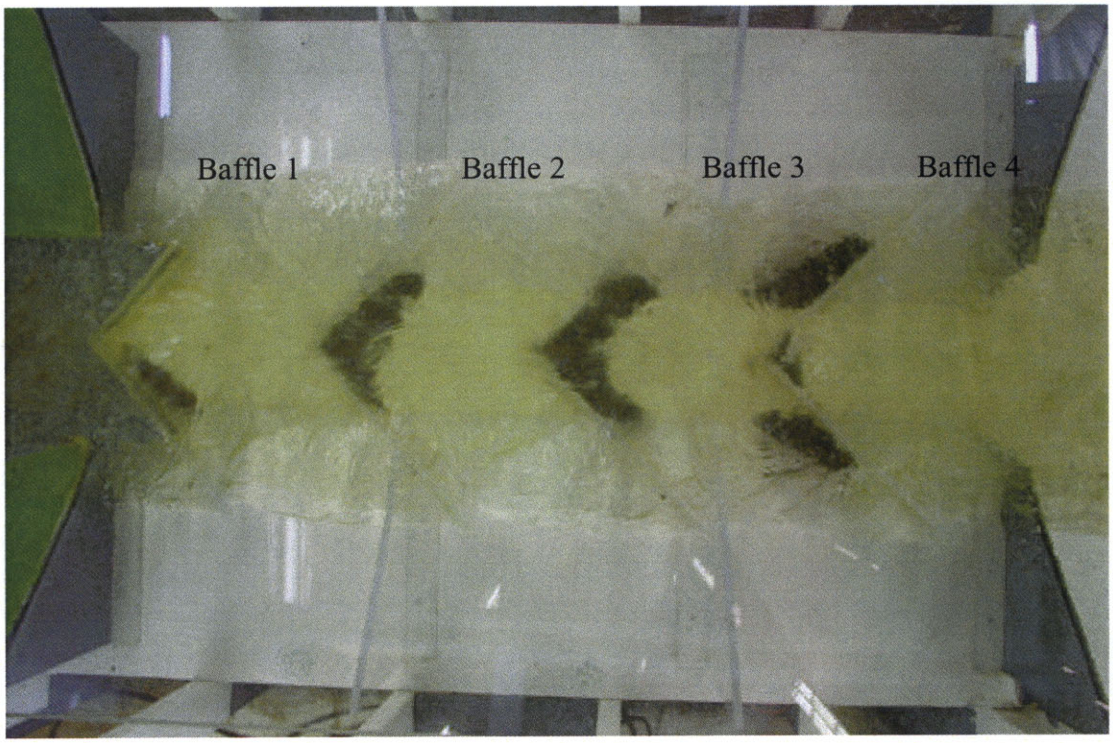


2) Sediment deposition patterns. Stevens Creek Discharge = 800 cfs.

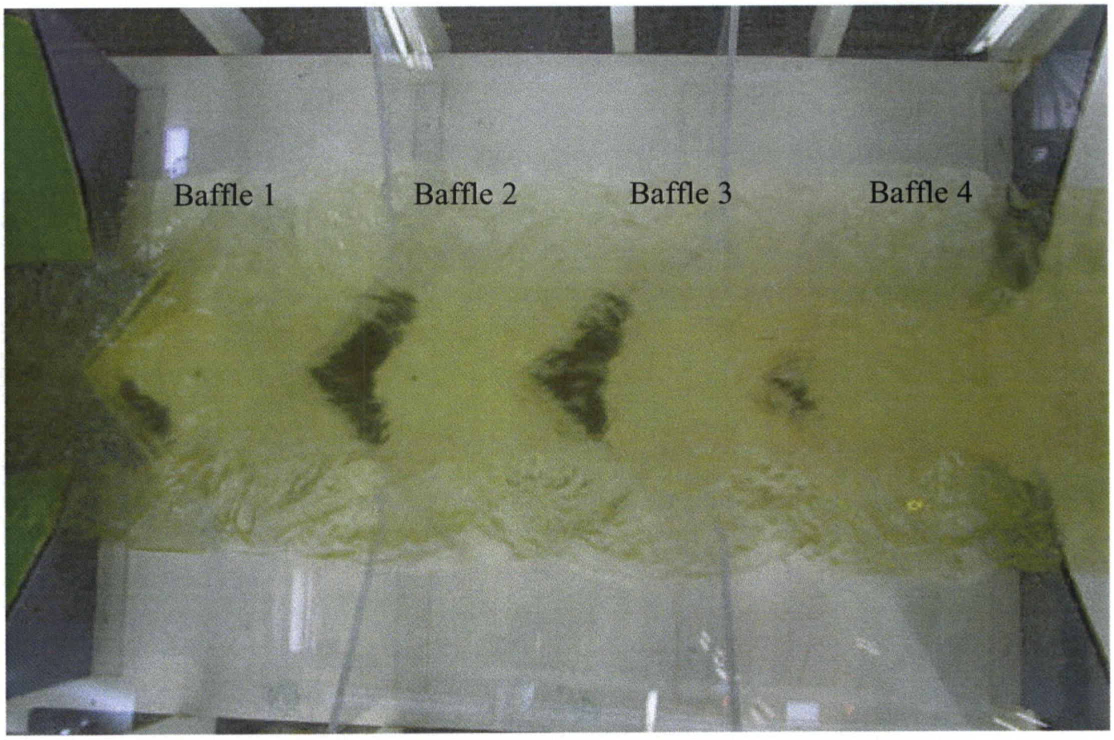
Stevens Creek Drop Structure Modification Project
Physical Hydraulic Model Study

Sediment Deposition - Stevens Creek Discharge = 600 and 800 cfs

PHOTO PLATE 4-4



1) Sediment deposition patterns. Stevens Creek Discharge = 1,000 cfs. Note that sediment is deposited along the upstream face of Baffle 4.



2) Sediment deposition patterns. Stevens Creek Discharge = 1,200 cfs. Note that sediment has not deposited upstream from any of the baffles.

Sediment Deposition - Stevens Creek Discharge = 1,000 and 1,200 cfs

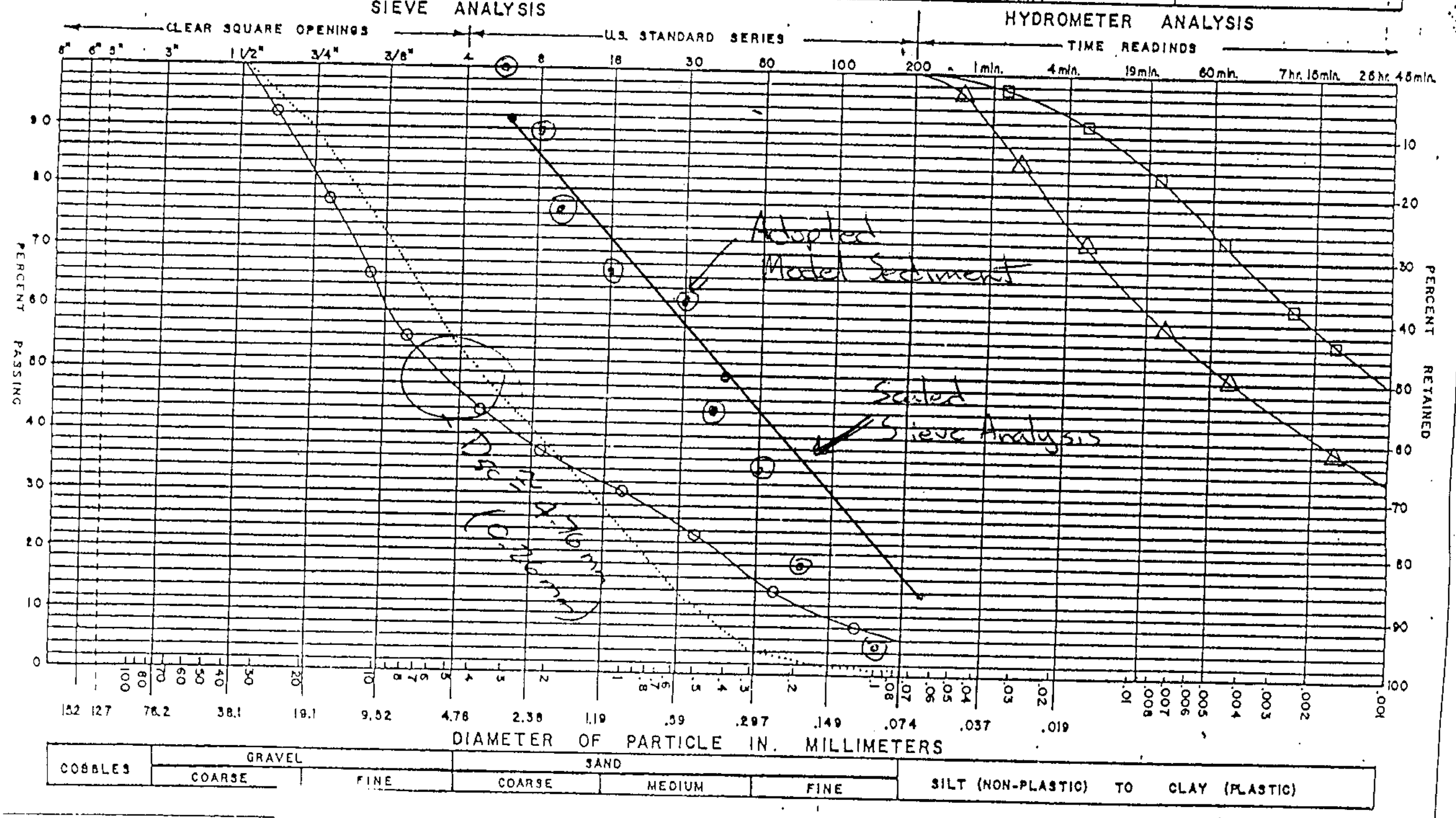
RESULTS OF GRADATION TEST

(ASTM E-11-70 & D 422)

JOB NO. 915-40

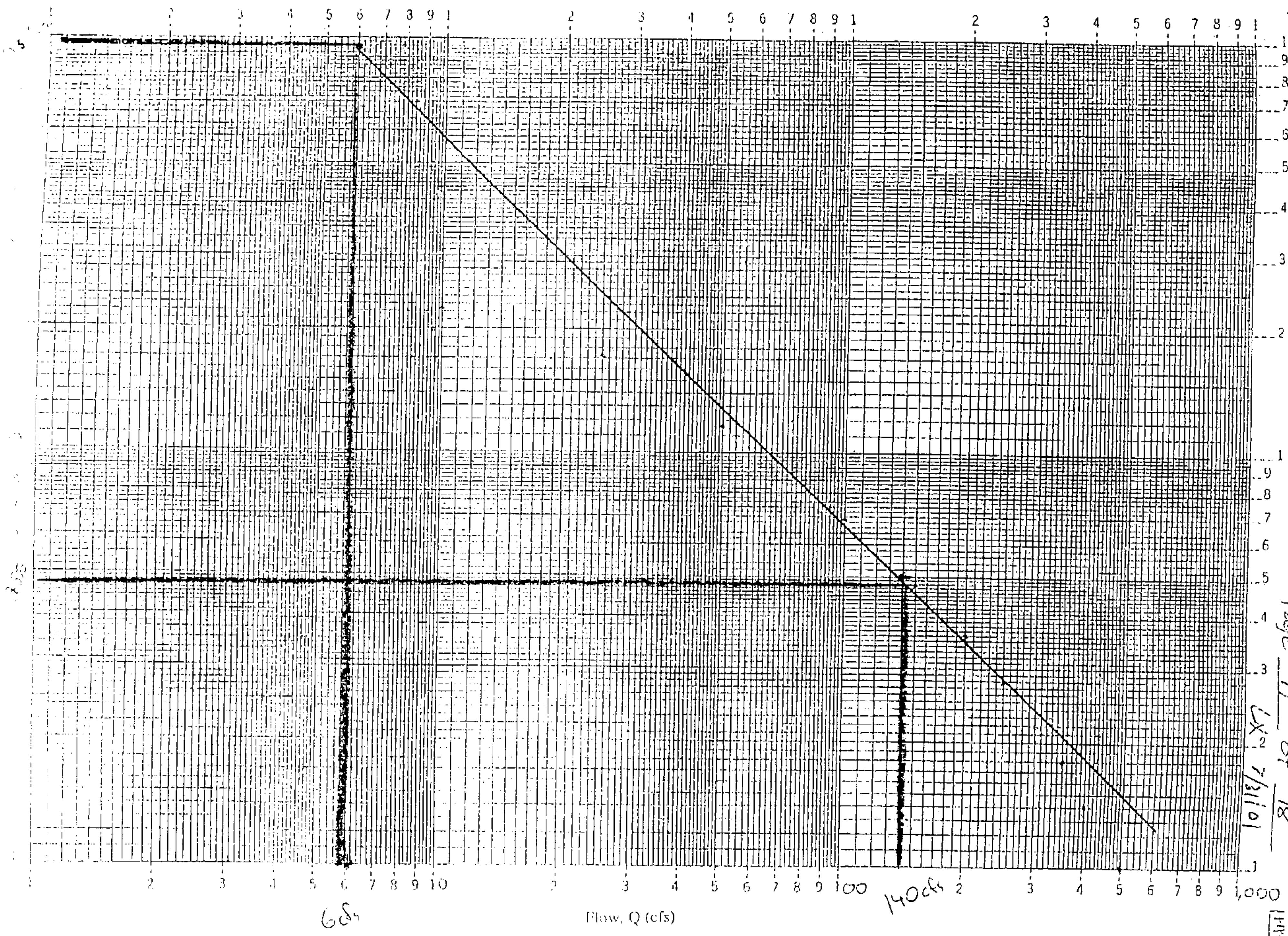
JOB NAME STEVENS CREEK

KEY	—o——o—	—□——□—	…………	—△——△—	
BORING NO.	B-2	TP-1	TP-6	TP-20	
DEPTH IN FEET	9'	4'	0-2'	3-8.'	
CLASSIFICATION	GW-GM	CH	SW	MH	



Sheet 8 RFP- Stevens Creek Drop Structure Model Study 8/02

[illegible] Analysis for [illegible] Migration [illegible]
at Stevens Creek Stream Gage Station 35



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LX 7/31/01

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